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Pacific Herring Tagging from 1936-1992: A Re-evaluation of Homing Based on Additional Data

D.E. Hay, P.B. McCarter, and K. Daniel

Fisheries and Oceans Canada
Biological Sciences Branch
Pacific Biological Station
Nanaimo, BC
V9R 5K6

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ABSTRACT

Federal fisheries agencies in British Columbia started tagging and recovering Pacific herring (*Clupea pallasi*) in 1936. The earliest tagging programs (1936-1967) used metallic 'belly tags' that were inserted into the body cavity and recovered with magnetic detectors in reduction plants. More recent tagging programs (1979-1991) used plastic 'anchor' tags that were visually detected, usually in fish processing plants but also by fishers and others. There are several previous publications on results of belly tagging programs but the results of the anchor tagging studies have not been fully reported. Recently, the data from both tagging projects, including some unpublished data, were incorporated into a single electronic database. This revised database is relatively large, with about 1.6 million releases and 42,000 recoveries. The new data and new format provides analytical opportunities that were not possible in earlier analyses. This paper presents an analysis of the combined belly and anchor tagging data to comment on the issue of 'homing' in herring. The most recent tagging data, however, are from the most recent anchor tags released in the roe fishery. The authors use these data, plus the revised belly tagging data and included in the analyses the time at large (time between release and recapture), which was not included in previous analyses. They present analyses that examine apparent 'homing' rates vary as a function of: (1) the types of tag used (anchor versus belly tag) and the fishery and related recovery systems; (2) the season or month of tagging; (3) the period or duration between tag release and tag recapture, in months or years; (4) the geographical size of the area designated as the 'return' area, varying from very small 'Locations' (i.e., < 100 km^2) to very large 'Regions' (i.e., ~10000 km^2). The authors interpret the results in the context of the current concern about the structure of British Columbia herring populations and make recommendations for future management and research.

RÉSUMÉ

Les organismes des pêches fédéraux situés en Colombie-Britannique ont commencé à procéder au marquage et à la récupération de harengs du Pacifique (*Clupea pallasi*) en 1936. Les premiers programmes de marquage (1936-1967) faisaient appel à des « étiquettes métalliques » internes placées dans la cavité abdominale et récupérées ensuite à l'aide d'un détecteur magnétique dans les usines de transformation en produits secondaires. Les programmes de marquage plus récents (1979-1991) faisaient appel à des étiquettes de plastique de type « ancre » pouvant être décelées visuellement, généralement dans les usines de transformation du poisson, mais aussi par les pêcheurs et d'autres personnes. On compte de nombreuses publications sur les résultats du marquage interne, mais les résultats des études par étiquettes ancrées n'ont pas tous été rapportés. On a récemment versé les données des deux types de programmes de marquage, y compris certaines données encore inédites, dans une même base de données électronique. Cette base est relativement importante regroupant environ 1,6 million de marquages et 42 000 récupérations. Ces nouvelles données et ce nouveau format permettent d'effectuer des analyses qui étaient auparavant impossibles. Le présent document fait état d'une analyse des données de marquage combinées étiquettes internes et ancres dans le contexte du « retour au lieu de naissance » chez le hareng. Les données les plus récentes ont trait aux étiquettes de type ancre utilisées pour les poissons faisant l'objet de la pêche pour les œufs. Les auteurs ont utilisé ces données, ainsi que les données révisées du marquage interne, et tenu compte dans leur analyse du temps passé en mer (entre la remise à l'eau du poisson marqué et sa recapture) dont il n'était pas tenu compte au cours des analyses antérieures. Selon leur analyse du taux de retour apparent, celui-ci varie en fonction : 1) du type d'étiquettes utilisées (ancre plutôt qu'étiquette interne), de la pêche et du mode de récupération; 2) de la saison ou du mois du marquage; 3) de la période ou de la durée entre le marquage et la recapture, en mois ou en années et 4) de la superficie de la zone désignée comme zone de « retour » qui va de « lieux » très petits (<100 km^2) à des « Régions » très grandes (~10 000 km^2). Les auteurs interprètent les résultats dans le contexte des

préoccupations actuelles au sujet de la structure des populations de hareng de la Colombie-Britannique et ils formulent des recommandations visant la gestion et la recherche à effectuer.

Introduction

Federal Fisheries agencies in Pacific herring in British Columbia have tagged and recovered Pacific herring (*Clupea pallasi*) since 1936. The earliest tagging programs (1936-1967) used metallic 'belly tags' that were inserted into the body cavity and recovered with magnetic detectors in reduction plants. Results and interpretations were published (Hourston 1982). More recent tagging programs (1979-1991) used plastic 'anchor' tags that were visually detected, usually in fish processing plants but also by fishers and others. The results of the anchor tagging studies have not been fully reported. Recently, the data from both tagging projects were incorporated into a single electronic database (Daniel *et al.*, 1999). This paper presents a re-evaluation of the data, presents new analyses of the combined belly and anchor tagging data, and comments on the issue and implications for 'homing' in herring. First we present an overview of the past programs showing the places and dates of tag releases and recoveries. Then we present analyses that examine how apparent 'homing' rates vary as a function of definition of the homing area: large areas will appear to have high homing rates, small areas have lower apparent homing rates. The geographical size of the area designated as the 'return' area may vary from very small (i.e., ~100 km^2) to very large areas (i.e., ~10000 km^2). We also show that the apparent homing rate is affected by duration of the period that the tagged fish are at large and the season of tag release and recovery.

This paper should be regarded as a preliminary analysis of the recently revised tagging data, although some of the most important results and conclusions will not change with further analyses and refinement. We present this paper now, however, to address this current issue about stock structure in Pacific herring. In particular, we want to document the available evidence that shows that many herring move extensively throughout the BC coast. As well, we also present evidence that some do not. We suggest that this information is essential to assist managers with decisions on future herring fisheries. Further, we hope that the tabling of these results at the present time will assist with the planning of any future tagging programs and the planning and interpretation of concurrent analyses of herring stock structure though genetic analysis.

Methods and Materials

The tags

During the 1936-1967 tagging experiments, tags were nickel- or silver-plated iron rectangles with rounded ends (19 mm long, 4 mm wide and 1.6 mm thick (Hart and Tester, 1937). Tags were inserted in a small incision into the body cavity (Hart and Tester, 1937). Beginning in 1979, herring were tagged with anchor tags that were made of a plastic tube attached to a monofilament T-shaped end that was inserted into the dorsal musculature (Haegele, 1981).

Tagging data records

Pacific herring were first tagged in British Columbia in 1936 and in most of the following years until 1992 and results were documented annually (Daniel *et al.*, 1999). Most of the early results, from 1936-1957, were published in annual publications of the British Columbia Provincial Department of Fisheries (Hart and Tester, 1937-1940; Hart *et al.*, 1941 and 1942; Stevenson, 1950; Stevenson *et al.*, 1952 and 1953; Stevenson and Lanigan, 1951; Stevenson and Outram, 1953; Taylor, 1955; Taylor *et al.*, 1956 and 1957; Taylor and Outram; 1954; Tester, 1944-1946; Tester and Boughton, 1943; Tester and Stevenson, 1947 and 1949). More recent results were published in other reports, mainly the Department of Fisheries and Oceans Data, Industry, Manuscript and Technical Report Series and Pacific Stock Assessment Review Committee (PSARC) working papers (Armstrong *et al.*, 1990; Farlinger, 1986, 1988, 1989a, 1989b; Farlinger *et al.*, 1991; Haegele, 1981, 1984a, 1984b, 1984c and 1986; Haegele and Hopwo, 1984; Haegele *et al.*, 1982a, 1982b, and 1983; Hourston, 1981).

Tag releases

Early work attempted to tag and release at least 3000 herring per location (Tester, 1944). The early objectives were not to examine movements. Rather the intention was to determine the cause of natural fluctuations in abundance and the average minimum spawning stock necessary to provide maximum sustainable yield (Tester and Stevenson 1947). Stevenson and Lanigan (1951) also suggested tagging would provide critical data needed to calculate the rate of exploitation from one season to the next. Later work was directed at analyses of migrations and stock relationships. For example, the 1957-1967 adult herring tag releases were designed to examine migration differences between herring in the northern and southern parts of the Strait of Georgia. (Taylor, 1973a). Also, in 1957, summer herring were tagged to determine the relationships between stocks fished in summer "offshore" localities with those of the regular, winter fishery (Taylor, 1973a and 1973b). The 1964 tagging program in the Queen Charlotte Islands (QCI) attempted to differentiate between QCI herring and other northern and central populations (Fig. 1). The 1965-1967 tagging examined the relationship between offshore summer and inshore fall fisheries. Between 1953 and 1959, herring tagging was completed in Washington State to examine the extent of intermingling of herring stocks from Puget Sound and adjacent waters, and to determine if these stocks contributed to the Canadian fishery.

The development of the roe fishery led to a renewal of the herring-tagging program in 1979 (Haegele, 1981). Pilot studies examined recovery rates from fish plants (Hay *et al.*, 1979a and 1979b) and the tag retention and survival of tagged fish in captivity (Hay, 1981). The coast wide tagging program was later suspended mainly due to lower than expected returns during the 1980-1981 fishing season (Haegele *et al.*, 1982a). Between 1986 and 1992 additional tagging was conducted, primarily in the northern part of British Columbia to "examine incoming

migrations of herring to the spawning grounds and their contribution to the fishing locations within the stock boundaries" (Farlinger, 1989a). Approximately 500-1000 tags were applied per tagging location (Farlinger, 1989a and 1989b). During the 1990 roe herring season, herring tagging was extended along the entire coast of British Columbia (Armstrong *et al.*, 1990).

Tag recoveries

Belly tag recovery occurred mainly in fish plants located along the British Columbia coast. Tester (1945a) differentiated between induction and magnet recoveries by stating "the former recovers the tagged fish from a chute in the unloading system of canneries or reduction plants; the latter recovers the tag only, from a meal-line of reduction plants". The main advantage of the induction detector was the greater certainty in determining the tag recapture location and the entire fish could be examined (Hart and Tester, 1939). The magnetic detector did not provide the same degree of recovery precision. The installation of induction detectors, however, was expensive and required constant maintenance by herring investigators (Hart and Tester, 1939). The magnet detectors were less expensive to run and, consequently, large quantities of tags could be recovered at little expense (Hart and Tester, 1939).

The rate and number of tag returns were influenced by many factors. In 1942, small monetary rewards were offered using posters in workplaces to encourage tag returns from canneries and reduction plants. Returns without rewards, however, were received in the first year (Tester and Boughton, 1943). A greater number of magnet recoveries during the 1948-1949 season was attributed to an increase in the use of magnet detectors, a higher number of fish tagged on the WCVI, and a greater interest by plant crews to collect tags due to the rewards (Stevenson, 1950). A decline in herring catches in the 1949-1950 season resulted in a decrease in the number of recovered herring tags.

Juvenile herring tags were only recovered during the 1950's by magnet detectors in reduction plants (Taylor *et al.*, 1957). During the 1954-1955 season, several tag detector problems were documented. Many tags were thought to be missed because the tag impulse frequency was in the same range as variations in line voltage (Taylor, 1955). Hourston (1956) suggested the reasons for lower returns were (1) the size-selective effect of the fishery and (2) differential mortality in the tagged fish, specifically stresses on tagged herring. Also, high water temperature, abnormal salinity and poor feeding conditions were identified as possible reasons for lower returns in some periods (Hourston, 1956).

During the 1968-1969 season, all herring fishing for reduction purposes ceased and only bait and food fisheries were permitted (Taylor, 1973a). Therefore, no tags were recovered after the 1968-1969 season when the reduction fishery was closed. In 1979, anchor tagging was initiated in the new fishery for roe. During the 1980-1981 herring fishery a $2.00 reward was offered for any herring tags recovered during the fishery (Haegele *et al.*, 1982b). Despite this reward, tag returns for that season were lower than expected. Haegele *et al.* (1982b) proposed that vessel crews did not properly tag the herring or handle them properly thus increasing their vulnerability to predation. Also, during this season, 30% of the recoveries occurred in the food

and bait fishery and the remaining 70% during herring roe processing (Haegele *et al.*, 1982b). The incidence of uncertain or unknown recovery locations increased during the 1982 roe fishery due to the fact that most of the catch was frozen and not processed until June (Haegele *et al.*, 1983). Since roe processing was usually completed by late July, Farlinger (1988) considered all tag returns were complete by mid-August.

Tag recovery precision

A major difference in the recovery information between belly and anchor tags is that the date of belly tagging recoveries is **known only to the nearest year**. Most belly tags were recovered using magnetic detectors in recovery plants and then retrieved at the end of the season. Also, the locations of many belly tags recoveries were not exact, and were often reported as being from one of several possible areas, usually within a broad geographic area such as the Strait of Georgia, or west coast of Vancouver Island (Daniel *et al.*, 1999). In contrast, the anchor tag recoveries were usually reported exactly, including the day of recovery, and usually with a precise geographical location, corresponding to a roe fishery opening (Daniel *et al.*, 1999).

Revised database structure

All tagging data entered into a new herring tagging database combined results from both the belly and anchor tagging work. Mainly this included previous published data and some new, unpublished data from more recent anchor tagging work in the late 1980's and 1990's. A summary tagging report by Hourston (1981) was used as the initial source for all 1937-1967 tag releases entered into the database. This report lists herring tag release locations, release dates and numbers released. These data were compared with release tables in each of the BC Department of Fisheries reports (1937-1957). The BC Department of Fisheries reports were used as the source for the 1937-1957 tag recovery data. Summary tables in Hourston (1981) could not be used because individual tag recoveries were not recorded. Also, recovery dates and location were presented with greater precision in the BC Department of Fisheries reports. These reports also have separate tables for induction detector, plant crew and magnet detector recoveries. However, magnet detector, induction detector and plant crew tag recoveries were not distinguished in the tagging database. In the 1937-1938 report (Hart and Tester, 1938), Ucluelet and Galiano detector recoveries were separated. In most other cases, however, all induction detector recoveries were summed together for the entire coast. Italicized numbers in the tables indicated a higher level of certainty, however, actual tag recoveries (bracketed in the tables) were entered into the database rather than adjusted recoveries. The adjustment calculation was not performed consistently or defined clearly in the reports. Descriptions of tag recovery locations were provided, but only tag recoveries listed in tables were entered. Occasionally, a statistical area number was listed rather than an actual location name so that the location had to be ascertained by the description. In cases where the fishing season was the only source for the date, (e.g., 1946-1947 fishing season), the latter year was entered as the recovery year. Tag recoveries at a single location were summed for a particular season and source group, checked against Hourston (1981) and then entered into the database.

Hourston (1981) listed a total of 49 juvenile tag release sessions. Many of these juvenile recoveries were not listed in the BC Department of Fisheries reports, but instead in a series of Pacific Biological Station Manuscript reports (Hourston, 1952, 1954a, 1954b, 1955, 1956, 1957). Sometimes multiple recovery locations were listed for a single or group of tags from a tagging release location. Also, in a table footnote, Hourston (1955) stated "alternative possible localities of recovery are given in parentheses". These recoveries were consequently entered into the database as multiple recovery positions.

Summer and winter fishery tag recoveries from 1957 to 1967 were entered into the database using Taylor (1973a and 1973b) as the data source. Taylor (1973b) tabled both certain and questionable recoveries. Questionable recoveries were due to the observation that "plants received and processed fish in quantity from several areas at once. There was no way of knowing which areas contained tags. All such areas were therefore considered as possible but uncertain or questionable areas of recovery." (Taylor, 1973a). Since many of the recoveries from the BC Department of Fisheries reports were documented in this manner (e.g., statistical areas 13-19) the questionable recoveries from Taylor (1973b) were also entered into the database as multiple recovery positions. The 1964-1965 winter fishery questionable recoveries (Taylor, 1973b), however, could not be entered into the database. This table did not list the possible areas of recovery, but instead listed only the total questionable recoveries. Furthermore, all recoveries in Taylor (1973b) were listed as statistical areas and sections except for the Swiftsure Bank recovery location. The 1957 summer fishery recoveries and 1958-1959 winter recoveries for Holmes Harbour and Hood Canal (Taylor, 1973b) could not be entered until referring to a Taylor (1973a) technical report. Recoveries could not be linked with releases because the tagging year was missing in Taylor (1973b), but the year was given in Taylor (1973a). Questionable winter fishery tag recoveries were not recorded in Hourston (1981), but questionable summer tag recoveries were recorded.

Haegele (1986) summarized herring tagging and returns from 1979 to 1985. Tag information in Haegele's (1986) report was compared with each individual annual report in the same manner as Hourston (1981) and BC Department of Fisheries reports were compared. Only data in Haegele (1986), however, was entered into the database because it contained all the data from all the individual reports. Unlike most early records, tag recoveries had exact locations and precise dates (year, month and day). Some tag releases were summed and entered when there were several smaller tag releases listed separately at the same location within a period of 1-7 days. The date entered into the database was always the first day of release at that location.

Herring tag releases and recoveries from 1986 to 1992 were entered into the database from several unpublished data sources and PSARC (Pacific Stock Assessment Review Committee) working papers. Tag release data was located in PSARC working papers (Armstrong *et al.*, 1990; Farlinger, 1988, 1989a and 1989b; Farlinger *et. al.*, 1991), however, tag recoveries were listed only in unpublished tables. The unpublished recovery tables did not always list the actual tagging location but only the statistical area name. Therefore, the tag series numbers (e.g., H472001) recorded both in these unpublished tables and the PSARC papers were essential in order to link releases with recoveries. Some tag releases or recoveries from the same

location, but a few days apart, were summed before entry into the database. Also, the date entered into the database was always the first day of release at that location. All unpublished data from 1986-1992 tagging programs were photocopied to facilitate subsequent retrieval. The revised database was designed in Microsoft Excel© so that all herring tag releases and recoveries between 1936 and 1992 could be included. The complete database is presented in Daniel *et al.* (1999). A brief description of the key main names and variables is listed in Table 1.

Geographic scales and recovery precision

An important aspect in the data structure and analyses is the differing levels of 'precision' about tag recovery information, mainly the date of recovery and geographical code of the recovery location. The exact location and date of release is known for all tag releases but the accuracy and precision of tag recovery data varies. For virtually all of the belly tagging data, we know only the 'season' or year of recovery. This was because the metal tags accumulated in the reduction chambers of the meal fishery, and were recovered mainly at the completion of each season. For the same reason, the information on location of recovery varied. In order of geographical precision, from fine to general, most precise information would be from a 'Location Code' or name, followed by the 'Section', 'Statistical Area' and 'Region'. For instance, a tag recovered at a known location (i.e. Departure Bay, Nanaimo, 'Location Code 920') would be an example of the most precise information. If only the general location recovery area was known (i.e. between Nanaimo and Nanoose, then the information could be listed as within the 'Section' (i.e. Section 172), or the Statistical Area. During the reduction fishery, the plants often were able to identify the tag origins according to the Statistical Area of the fishery (such as Statistical Area 17). For many tags, however, the plants could determine only that the recovered tags were from a potential group of statistical areas, such as a range between Statistical Areas 14-18. If this range of Statistical Areas falls within one of the 6 'Regions' of the coast, then this would be the maximal level of geographic precision available. The 6 Regions are: (1) Queen Charlotte Islands (QCI), Prince Rupert District (PRD), Central Coast (CC), Johnstone Strait (JS), Strait of Georgia (SG) and West Coast of Vancouver Island (WCVI) (Fig. 1a-f). For many tags, no geographic information was available.

Estimates of tag recovery

The numbers of tags recovered were compared to the numbers released for (i) each year of release; (ii) each area of release at 4 different geographic units: the Region, Statistical Area, Section and Location; (iii) the numbers of years between release and recapture. For most tag returns some information was incomplete, such as the area or date of recovery. Usually, however, there was some information on the geographical Region of recovery. For instance, the Statistical Area of recovery might have been known, but not the Section or Location. Similarly, the year of recovery might have been known, but not the month, etc. Therefore, at all geographical comparisons, we only included data where the geographical units were known with certainty.

For any geographical area, there are two basic approaches to the analysis of the herring tagging data: a quantification of immigration, or emigration. To describe and quantify immigration, one asks: 'where did the herring come from?' or 'how many herring came from other areas?' These are questions asked about the origins of tagged herring *recovered* in a particular area. The other question to ask of the tagging data is: 'where did the herring go?' or 'how many left relative to the number that stayed?' These are questions asked about the eventual destination of herring *released* at a particular area. Both types of questions can be refined by consideration of different geographical scales or domains, such as the herring 'Location, Section, Statistical Area, or Regions' (Fig. 1). These questions may be asked of all the tagging data, regardless of the period that the fish have been free to move, or based only on a subset of data from fish that had been free to move for a minimal time, say one year. Further, the seasonal migratory habits of herring could be considered, because herring tagged and recovered in the summer may show different movements than those tagged in the winter. In this report we consider the ratio of tagged fish recovered from the same area in which they were released as a measure of fidelity.

Estimates of 'geographic' fidelity

The recovery site for each tag return was compared to the release site. This was done for each of the 4 geographic scales, (Regions, Statistical Areas, Sections and Locations). For each geographic scale recovered tags were either from 'residents or immigrants.' Tags that were released and recovered within the same domain were defined as belonging to 'residents' ('R') and (ii) tags from fish from other domains, or 'I' for 'immigrants'. If the total number of tags released in a single geographic domain (but eventually recovered in all domains) is 'T', the ratio R/T is an estimate of fidelity, or biological adhesion to an area, and will be between 0 and 1. The emigration rate is then 1-(R/T).

To estimate R/T for each domain, a recovery in the same geographical unit as the release was defined as '1' for a match. Mismatches between release and recovery areas were defined as '0'. Therefore, for each geographic scale, the sum of the matches was an estimate of 'R' and the sum of the mismatches was an estimate of 'I'. Both R and I can be estimated for any combination of years of release, or years at large, or geographical scales. The area-specific fidelity rate (R/T) is not affected by the numbers of tagged immigrant fish (I) that enter an area from other Regions. Therefore, fidelity estimates are specific to each area.

Estimates of north-south movement

The movements of herring, within and among different Regions between tagging and recapture was estimated as follows. If a herring was recaptured in any Region north of its release Region, it was considered as a movement north and scored as 1. Similarly, a recapture to a Region south of the release Region was considered as a movement south and scored as -1. Lateral movements were scored as 0. The movement matrix defined by the arrays of each Region is shown below:

		Recovery					
		QCI	PRD	CC	JS	SOG	WCVI
R							
e	QCI	0	0	-1	-1	-1	-1
l	PRD	0	0	-1	-1	-1	-1
e	CC	1	1	0	-1	-1	-1
a	JS	1	1	1	0	0	0
s	SOG	1	1	1	1	0	0
e	WCVI	1	1	1	1	0	0

The sum of movements was arrayed by year and by different Regions, to compare northward and southward movements.

Results

Spatial and temporal distribution of released and recovered tags

A total of 1,595,249 herring tags were released between 1936 and 1991, and recovered until 1992. Tags were released in a total of 955 different capture and release sessions (Table 2). Approximately 85% of these release sessions resulted in some eventual tag returns. A total of 42,767 tags were recovered, for an overall mean recovery rate of 2.68%, but this varied annually. The annual recovery rates (Table 3) vary from a low of about 0.5% to a maximum of over 11%. For any particular year the annual recovery rate represents tags released in a single year but recovered from over a number of different years. Therefore, the annual recovery rates in Table 2 may be affected by a number of factors, including:

(i) differences in annual fishing rates and locations of fisheries;

(ii) differences in recovery rates according to the time between tagging and recovery. In a few instances, large recoveries were made very shortly after releases;

(iii) area-specific differences in recoveries.

Of these 3, we do not attempt to adjust tag recoveries according to fishing catch data or fishing rates in this report but we acknowledge that this is a vital step in the analyses of tagging data. This approach, however, will require that the historical catch data be updated to show more detail about the dates and times of catches. Also, the catch database should be extended to include the years between 1936 and 1950, which are not included in the present catch database, although this period is well represented in the tagging database. Revision of the catch database is a major task and work on this is underway at the present time.

During all years, most of the tags (76%) were released during the pre-spawning and spawning periods from February to April, and over 57% of the tags were released in March (Table 3). There were relatively few tags released during the summer months, from May until

August. In most instances, however, we do not know the season or months times of recapture, but we do know the year of recapture.

The numbers of returns, shown according to the year of release, and the numbers of years between the release and recapture is shown in Table 4. Many belly tags were captured after several years and a few were at large for 10 years. Most tags were recovered after 1 year at large. The subsequent annual rate of recapture was quite consistent at about 0.32 (Table 5). This is determined as number (n) of recaptures after y years of release (n_y), divided by the number recaptures in after $y-1$ years of release. The estimate of n_y/n_{y-1} is very consistent with an approximate rate of 0.32 for belly tags the first 3 years (Table 5). This estimate would be affected by several factors, including annual fishing rates, the numbers and locations of tags released, natural mortality, tag retention and tag detection. The numbers of tags recovered from the anchor tags, after the first year, is much less, with about only 10% of the fish captured after 1 year, relative to the number captured in the first year. A total of 81 anchor tagged fish were recaptured after 2 years, or about 17% of the number captured (482) after 1 year. The lower rated of capture in the anchor tagged fish could reflect the lower fishing rates during the 1980 roe fishery of the 1980's and 1990's and, higher mortality rates of tagged fish (some tags were returned from salmon anglers who found the tags in salmon guts). Further, tag retention may have been a problem because of a tendency for the tags to dislodge from some fish (Hay, 1981). The dates of most recaptured belly tags is unknown, except for the year, but the recovery month was usually reported for the anchor tags (Table 6a). Unfortunately, most of the anchor tagging returns were recovered in the first year, so the months of recapture, on tags at large for 1+ years, is much lower, but most were recovered in March (Table 6b).

Geographic fidelity

The recovery of tags, released at the geographic scale of the Region is shown in Table 7. Of the 42,767 tags recovered, the Region of recovery is unknown for 8,311 tags. From Table 7a it is clear that herring movements are extensive: tags released in each Region were recovered in all other Regions, with the exception of the Queen Charlotte Islands and Johnstone Strait. Also from Table 7a, it appears that most of the tags recovered in each Region were released in that Region. Such a conclusion should not be based on the data in Table 7a because there was no allowance made for the time between release and recapture. Table 7b shows the distribution of tags at large for one or more years. In most instances, some tags released in one Region were recovered in nearly all other Regions. Most recoveries, however, were made in the Region of release. Table 7a also shows some release and recovery sites in US waters, although the numbers are low and are not included in the subsequent analyses. The data shown in Tables 7a and 7b can be expressed as percentages of recaptures. Table 8a shows the numbers of tag returns as a percentage of the release Region (rows) and recovery Region (columns). The rows marked as "% F" are an estimate of the fidelity rate (R/T). The extent of immigration can be seen from the estimate of "% I" which is the approximate proportion of fish captured in each Region that were tagged in the Region.

The approximate estimate of immigrants in each of the Regions can be estimated by

subtracting the '% I' from 100% (the column total). From Table 8b, which provides estimates based on tags at large for 1 or more years, the immigration rates are as follows: QCI – 11%, PRD - 19%, CC - 10%, JS – 32%, SOG – 16% and WCVI – 3%. Although the analysis of the tag return data based on fish at large for 1 year (Table 7b) should be superior to that from the complete data set (Table 7a), the differences in estimates of fidelity, examined at the geographical scale of the Region, are not very different from the estimates based on the entire data set.

The same analyses of fidelity shown in Tables 7 and 8 for Regions can be done at finer geographic scales such as the Statistical Area, Section and Location. There are too many combinations to show matrices of releases versus returned for the Section and Location levels, so these will be presented differently. We have, however, attempted to show the release:recovery matrix at the Statistical Area level (Table 9a-c). These comparisons include only tags that were at large for 1 year or longer. Table 9a shows only the *numbers* of tag returns. Tables 9b shows the recovery *percentages* as a function of the total number of tags released in each Statistical Area, and this is an estimate of *R/T*, the 'fidelity index'. Table 9c shows the returns as a percentage of the number of tags recovered in each Statistical area. Reading down the columns in Table 9c, the numbers indicate the destinations of released fish as they moved among the different Statistical Areas.

The comparisons shown in Table 9 are not filtered by the times of release, so these tables include some tag returns that were released during non-spawning seasons. This is important because the tag returns for Statistical Area 21, which is not a herring spawning area are very high. Therefore, this estimate of 'fidelity' is not related to the return of herring to spawning areas. We discuss this further, below.

The mean fidelity rates are shown from different geographical scales in Table 10a-c, according to the number of years between release and recapture for all tags returns. For each year at large (from 0 to 6 years) the proportion of tags recovered in the same geographical unit in which they were released is shown. After 1 and 2 years at large, the overall mean fidelity rate to the Region is about 0.9 (Table 10a). Fidelity to the Statistical Area was about 0.5–0.6, but about 0.17-0.24 to the Section (Table 10c). Mean fidelity to Locations was about 0.01-0.02 but this is not presented for individual Locations). These estimates are relatively similar when calculated from all releases, or on the releases selected between fish spawning from January to April or March. This reduction in fidelity associated with the size of the recovery area is illustrated in Fig. 2, which was based on the fidelity rates of all returns after 1 year at large.

From these analyses we suggest that there are two key observations: (1) The first is that some herring move a lot among different areas of the coast. Probably between 10-20% are recovered in different Regions than their release Region. The estimate of movement is dependent on the geographical scale of analyses: analyses at larger scales indicates smaller movements and vice versa. (2) Some herring have very high fidelity rates and are recovered in nearly the exact place of tagging, even after a period of years. This is seen in the low but consistent fidelity rates estimated for the section level. There may be a presumption by some that these high fidelity rates represent high 'homing' rates. This is not necessarily the case and it is

just as probable that some individuals do not migrate from areas, or have smaller seasonal movements. Therefore, with the present data it may be impossible to distinguish between fidelity rates associated with 'homing' and those that reflect a sedentary (non-migratory) life history. For this reason, we avoided the term 'homing' in the previous discussion. The presentation of these estimates, however, also can be misleading if not considered carefully. An illustration of this is the high fidelity estimate (0.97) for Statistical Area 21. This Statistical Area is mainly in offshore waters and is not a herring spawning area. Therefore, this fidelity rate should not be considered as a 'homing' rate to natal spawning areas.

The most stringent analyses of the tag return data is obtained by restricting the tag returns to (i) those that were released during the 3 month spawning season (February to April) and (ii) recovered during the same period (February to April), 1 or more years later. These estimates are shown in Table 11, and we suggest that these are the best 'fidelity' estimates that might correspond to 'homing' rates. These data represent fish that were tagged and released in the spawning periods and recovered in subsequent spawning periods. This time restriction nearly eliminates all belly tag return data because recovery dates are unknown for most of these data. To meet the criterion of 'homing' between spawning periods, fidelity estimates should be based only on fish that have been at large for one or more years. The total number of useful tag returns which meet these criteria is 395 (321 returned after 1 year, 60 after 2, 8 after 3, 5 after 4 and 1 after 5). The estimates for the movements within the first year (0 years at large) are not meaningful relative to the issue of the return to spawning areas year in the years following tagging.

In general, the fidelity estimates made at the level of the Region Table 11a) are slightly lower than the previous estimates with a mean fidelity index after 1 year at large of 0.78, and 0.82 after 2 years. The estimate for fidelity to each Statistical Area (SA) varies, with an overall mean of 0.568 but large differences among some SA's (Table 11b). Among the highest are SA2 (0.729 after 1 year), SA 5 (0.72 after 1 year), SA 7 (0.82 after 1 year) and SA 23 (0.84 after 1 year). In general, the fidelity rates estimated for Sections (Sec) are lower, but there are a few which are of interest (Table 11c). Within the PRD, Sec42 (Chatham Sound) is 0.6 (n = 5) and Sec52 (Kitkatla) is 0.72 (n = 12). Also noteworthy are the high fidelity rates to Sec72 (Spiller Channel) at 0.69 (n = 13), Sec142 (Lambert Channel) at 0.67 (n = 12) and 232 (Macoah Passage) at 0.75 (n = 38) because each of these is within one of the existing stock assessment areas. One implication of these data is that they may be taken as evidence of homing to different discrete areas within the boundaries defining the existing Stock Assessment Regions (Fig. 1). This conclusion may not be warranted, however, because both the release and recovery dates span a period of 3 months. Therefore, it is possible that many of these tag return data (Table 11c) that show high fidelity to specific Sections, represent fish that were tagged and released before they reached their exact spawning destination or recovered after they had previously spawned elsewhere, perhaps in a different Section. This aspect of these analyses can be examined more carefully in a future report. Specifically, we suggest that for a subset of the anchor tag data (those released in the spawning period and recovered one or more years later in the spawning period), and particularly those data showing high fidelity rates to Sections, the dates of tag release and tag recovery should be compared to the recorded spawning dates in the herring spawning data base. The dates of tag recovery, if made in a fishery, should be compared to the

dates and places of fisheries and then these should be compared to the records of spawning dates and places. This proposed analysis may show that some of these Section-specific tag recoveries were not made in the immediate vicinity of spawning areas. On the other hand, the analysis may confirm the high fidelity rates to some specific spawning areas.

North-South movements

There appears to be a net movement of herring from southern to northern regions (Fig 3). This net movement is not consistent over time, and there seems to be a few periods (or episodes) when northward movement is more extensive. These analyses, however, should be considered as preliminary, and the potential effect should be examined relative to the catch sizes in all areas. For instance, if substantially more tags were released in some areas, over short periods, this could give the impression of a northward movement that might really be an artefact of the timing and magnitude of releases of disparate sizes between areas. Probably this is not the case, however, because during the belly tagging period and reduction fishery, both fishing and tagging were done extensively in all areas (Table 2). This net movement northward seems to be derived from fish tagged in March (Fig. 4) during the spawning period.

Discussion

This paper presents a revised analysis of the results of tagging data presented by previous authors, particularly Hourston (1982). In general, our results corroborate his general conclusions – as they apply to the 'Regional' scale of analysis and we concur with the previous conclusions that herring 'home' or have high 'fidelity rates' to different geographic 'Regions' (Hourston 1982). This conclusion, however, does not necessarily apply to finer geographic scales, such as the Statistical Area, Section or Location. Also, the term and concept of 'homing' may not be appropriate when applied at the level of the Region because in many instances, it is not clear if herring ever leave the Region. For instance, most herring that spawn on the WCVI, may make only short movements to shelf feeding areas off the WCVI, then return to nearshore waters of WCVI to over-winter and spawn, so they spend their entire lives within the WCVI Region. This also applies to most CC, QCI and many PRD herring, but not necessarily to SOG herring that are known to migrate in and out of the SOG. Therefore, a fish cannot 'home' to an area it never leaves. Instead, an area-specific estimate of 'fidelity' is preferable because it does not necessarily carry the connotation of 'homing' to a natal spawning area – as 'homing' does.

The revised analysis of herring tagging data indicates that the estimation of the fidelity rate is heavily dependent on geographic scale. Large areas, such as Regions have high fidelity rates, smaller areas have lower fidelity rates. For the purposes of illustration, one could consider exceptionally large areas, such as the entire BC coast, or the entire Southeast Alaska coast, or the Gulf of Alaska etc., as areas of release and recovery. Probably these relatively large areas would have a fidelity rate (as defined in this report) that would always be close to 1. At the other extreme, very small geographic limits, say 100 metres of shoreline, will almost always have a

low fidelity rate, close to 0. Therefore, at spatial extremes, the fidelity rates will either be 1 for large areas or 0 for small areas. The question of biological interest is the spatial scale at which the scale begins to increase above 0, and when it approaches 1. From the analyses in this paper, the fidelity to a spatial scale related to a 'Location' is close to 0. How big is a 'Location'? Clearly, these vary, but there are about 1500 defined location names used in the herring database (Haist and Rosenfeld 1988), and the BC coast consists of about 25,000 km (Hay 1985). Simple division gives an estimate of about 15 km of coastline per location. There are about 100 Sections for a mean coastline of about 250 km each and about 30 Statistical Areas for a mean coastline of about 800 km each. If each of the 6 Regions are of approximately equal size, then there are about 4000 km of coastline per Region. The potential significance of this is that Regions have fidelity rates of 0.8-1.0, Locations have fidelity rate slightly greater than 0, and Sections and Statistical Areas are roughly intermediate, with some having fidelity rates of about 0.1-0.6. From this crude relationship, we suggest that the minimum spatial scale required for high fidelity rates would usually be the equivalent of the Statistical area or larger. We acknowledge, however, that there are many other factors than simple area that may determine fidelity rates, such as proximity to spawning areas, shoreline characteristics, bottom topography and prevailing oceanographic conditions, etc. Also, from these analyses, we would not rule out the potential for temporal changes in fidelity rates. From the analyses of 'north-south' movements, it appears that there could be episodic periods of several years or more when herring tend move, and other periods when they do not. If this assessment of episodic movements is correct, then we might look for a biological explanation, perhaps related to trophic conditions.

Compared to previous studies, in this report we were able to differentiate among the time of release and recapture, and eliminate tag returns with a short duration between release and recapture (i.e. < 1 year). We suggest that a strong conclusion from this report is that 'homing' or fidelity rates in Pacific herring are scale-dependent. Hourston's 1982 paper, along with others concerned with herring tagging (i.e. Wheeler and Winters 1984) are sometimes cited as evidence for high 'homing' rates in herring. The 'homing rates' that Hourston (1982) estimated for Regions, are sometimes cited as evidence that homing rates to smaller areas also is high. The results in this report refute such claims. Presently, there are concerns that may be distinct stock units *within* the 5 major assessment areas used to manage the BC herring roe fishery. In this regard, the results presented in this paper clarify some issues, but they point to the kinds of additional information we need. For example, the tag recovery data indicate that while most herring are recovered within the same Region as their release, some individuals move extensively: tags released in each of the 6 Regions have been recovered in each of the other Regions. Using the criteria of recovery of tagged herring one or more years after their release in Regions other than the Region of release, about 10-20% of herring move between Regions each year. These movements, however, may be episodic, and more extensive in some years than others. Therefore any future tagging or marking program that is not based on a long-term initiative, may be unable to address this aspect of movements. We suggest such movements may have significant impacts on some aspects of population dynamics. In particular, there appears to be a net direction of fish moving northwards, particularly from the CC to PRD, with about 20% of the tagged herring recovered in the PRD released in other Regions.

Although our main conclusions are that herring movements appear to be extensive

throughout the coast, is also seems clear that a few herring do not move. Some individuals were recaptured in the same sections or even locations years after they were released into those same areas. This implies a very high fidelity rate for some individuals, although it does not necessarily mean a high 'homing' rate. Instead, this apparent fidelity may reflect the life history of a non-migratory or sedentary fish that never really leaves an area. Therefore, the apparent contradiction between high rates of movements and some local instances of high geographic fidelity, may reflect the movements of 'migratory' fish versus 'non-migratory' fish. Except for the SOG herring, and perhaps some herring that inhabit mid-Hecate Strait, most BC herring may not have a life history that includes a regular migration out of each Region, although most would seem to move (or migrate) extensively within each Region. 'Migratory' herring, regardless of whether they move among Regions, may not show the same 'fidelity' to spawning areas as is shown by non-migratory herring. In the case of non-migratory herring, the return to the same spawning areas may not reflect active 'homing' as much as seeking the best spawning area, within their home range.

The issue of the status of non-migratory herring may be the most significant problem for current herring management. Although recent stock sizes and spawn deposition is high (Schweigert *et al.*, 1998) there has been a marked reduction in the amount of herring spawn in some areas (Hay and McCarter 1998) and an apparent decline in the numbers of herring that spend the summers in SOG. One potential explanation for this is that non-migratory herring represent distinct biological stocks, perhaps genetically differentiated, and that their numbers have declined. If so, any fisheries that could impact these depressed populations should be executed with caution. An alternate explanation is that these non-migratory herring are simply part of the major herring stocks that choose not to migrate. The option to migrate or remain resident may be trophically determined and affected by climatic conditions. In this regard, future tagging during the summer could provide a lot of useful information that has not been available from the previous investigations. In particular, the tagging of herring during the summer would reveal whether herring captured in the summer in local inshore waters (i.e., non-migratory herring') aggregate with the large spawning concentrations composed of 'migratory' herring. If they do spawn in the same areas, then the probability that either migratory or non-migratory herring represent any form of distinct biological population is very low, because reproductive isolation would be impossible.

If migratory and non-migratory herring do not spawn in the same area, then there may be potential for *genetic differentiation,* although not necessarily *reproductive isolation.* There may an example of this for Pacific herring that was observed in a study involving a year-round collection of herring maturity data from the southern Gulf Islands in SOG (Hay and Outram 1981). At one sampling period in the spring, there appeared to be an exotic group of herring present that were bigger but with reduced maturity states relative to the local population that was sampled in previous and subsequent times. In subsequent collections of samples, these 'exotics' disappeared. In this instance, the two apparent groups of herring probably did not spawn together, because they were at different stages of sexual maturity, but the samples were made in an area (Trincomali Channel) that is close to known spawning areas. Also, the two groups of fish may not have inter-mingled as individuals and could have been segregated into different schools that merged within the fishing gear (mid-water trawls).

Although these two groups of herring appeared to be 'biologically distinct ' such differences could arise from different ecological backgrounds, and they may not have been 'genetically' different. If tags had been applied at the time when these 'exotic' fish arrived, then the results of any subsequent recoveries could have been confounded, because the tags would have been released on a mixture of resident and migratory fish. In effect, tag return data could have *underestimated* the potential fidelity of each group. On the other hand, suppose these two groups were genetically distinct and suppose the samples for genetic analysis had been collected at the time when the two groups co-existed (both slightly prior to the spawning period). Without some corresponding biological data, it would be impossible to differentiate between these fish. Therefore, any genetic analysis that does not included some basic biological data (length, weight sex etc) would be confounded and potentially misleading. Therefore, we suggest that for the future analyses of genetics of BC herring, a concurrent collection of biological data is essential.

There is an interesting biological issue, related to the previous discussion and stemming from the results. A recent paper on herring genetics in Prince William Sound, Alaska (O'Connell *et al.*, 1998) concluded that herring were genetically differentiated *and* reproductively isolated among 3 areas within Prince William Sound, Alaska. Prince William Sound is approximately the same size as SOG. These putative distinct Alaskan populations are not geographically isolated in remote inlets or fjords, but are described as occupying different parts of the Sound (although no accompanying life history information was presented. O'Connell *et al.* (1998) acknowledge that there may be exchange of individuals among these alleged 'reproductively isolated groups' but suggest that only a fraction of the 'strays' which intermingle among the populations "*would represent genetically effective migrants*". This is a remarkable assertion, that one we suggest is extremely unlikely. What is a 'genetically ineffective' herring? In Prince William Sound, if it is a herring that has a fidelity rate <1, and if the exchange among the 3 populations is similar to the fidelity rates that we estimate for BC Statistical Areas in this paper, then this would include about 50% of all herring. In support of their claim, O'Connell *et al.* cite the tagging report of Hourston (1982) and others as evidence of 'high homing rates' and quote Hourston's homing rate of "83.6%". This report corroborates the high 'Regional' estimates of fidelity (or 'homing') rates estimated by Hourston (1982), but we also show that the rates are lower when estimated for smaller genetic areas, with a mean of 50-60% for Statistical Areas, although but much lower in SOG Statistical Areas, which are most likely to resemble the Prince William Sound situation. Therefore, our results should pose a problem for the interpretation of the Alaskan data because the straying rate among areas within the Regions (roughly similar to Prince William Sound) probably is much higher than they have assumed. It may also present a problem for the interpretation of any genetic differences found among some BC herring populations. That is, how can one explain any apparent genetic differences among populations when there is so much movement between them? There may indeed be a number of valid explanations, not all of which are associated with a hypothesis of *reproductive isolation* among the groups. Regardless, if the only argument to support the results of the Alaskan study is the assumption that migrants are 'genetically ineffective' then this is further reason to ensure that the future genetic data is collected in conjunction with biological data.

Recommendations

Fisheries management: There are two distinct recommendations for fisheries management related to assessments derived from this paper, one based on the relatively high fidelity rates and the other on the high rates of migration.

(1). One recommendation is based on the fidelity rates estimated for *some* Statistical Areas. It may be prudent and risk-averse to re-examine the issue of the Assessment Regions relative to all Statistical Areas with relatively high fidelity rates. Failure to do this may could result in local depletions but not necessarily a risk to genetic biodiversity.

(2) The second recommendation concerns the high rates of movement between the CC and PRD. Future assessments should be cognizant of the potential for inter-regional recruitment, and in particular, the movement of herring from the CC to the PRD. If the movement of such herring is mainly from young (age 2 and age 3) herring, reaching and spawning in PRD at ages 3 and 4, then this could have some impact on some assumptions about recruitment in the assessment models.

Herring research: There are 3 recommendations for future research.

(1) Future tagging or marking programs should be designed to provide information that is weak if not unavailable in the present data set. One concern is that some herring movements may be episodic. Therefore any tagging program that is not based on a long-term initiative will not be able to examine this. Extensive tagging programs that release many fish but ignore recovery systems may not provide much useful information. Of the 42,000 BC herring tag returns made over nearly 55 years, the most useful for analyses of 'homing to spawning areas' are about 500 returns from the 1980's and 1990's. Therefore, the recommendation for future tagging work is to ensure that reliable tag recovery systems are in place prior to the massive release of tags. If suitable tagging systems can be implemented, it would be preferable to conduct a smaller, but longer-term program than a large but short-lived program.

(2) Future genetic analyses should not be conducted on fish that are not also subjected to the routine biological analyses conducted for most samples. The reason for this recommendation is that at the present time, no one can explain the basis for genetic variation among different groups of herring. A recent genetic study argues incorrectly that high 'homing' rates (citing the historical data used in the present paper) account for the apparent genetic divergence in Alaska. The revised analyses in this paper do not support that conclusion and the explanation is in error. Perhaps some of the genetic variation among herring has other causes, including episodic migrations. If we are to ever understand this, future genetic data should be accompanied by basic biological information.

(3) The subset of tagging data based on anchor tag returns that were released and recovered in later years during the spawning period should be examined with reference to the herring spawn database and data on the times and places of fishing, during which most of the recaptures were

made. The objective of the proposed work, involving about 500 data points, would be to provide finer geographic and temporal information of the differences or similarities between the release and recovery of tags, relative to the 'homing' of herring to previously used spawning areas.

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Table 1. List of key names and variables in the revised, integrated herring tagging database.

Variable Name	Description
TagGroup:	A unique four digit numeric identity number for each group of tagged fish released. The first 2 digits represent the year of release and the last 2 digits representing a group release number (i.e., 8120 represents the twentieth group of tags released in 1980. This code is integral for all analyses.
Season and Group:	This letter code follows Hourston (1981), Taylor (1973) and in the B.C. Department of Fisheries reports. Tag releases were linked to recoveries using a 'Season' number and 'Group' letter code. This alphanumeric identification system was recorded in the database in fields 2 and 3, for cross-referencing and data checking purposes only. This alphanumeric system was discontinued in 1968.
Date:	Year, month and day of tag release or recovery.
Tagrole:	This code differentiates between releases and recoveries, and also distinguished between juvenile and adult releases. A juvenile release was specified as a "1", an adult release as a "2" and a recovery as a "3".
Position:	This code indicates the precision of a tag release or recovery location. An exact or single recovery location was indicated by a "1" and a multiple area of recovery (e.g., Central Coast - statistical areas 6-10) was indicated by a "9". Many of the tagging records prior to 1968, recorded tag recovery areas using a range of several statistical areas. This was done because boats fished multiple areas per landing and herring from different areas were often mixed at fish plants. The exact tag recaptured location could not be determined and instead, all probable statistical areas of recovery were listed.
Number of tags:	The number is the total number of tags released or recovered at each location and date.
Location Code:	A 4 digit numeric code documented by Haist and Rosenfeld (1988) which lists all British Columbia herring locations and their location codes. This code was used because it could be linked to an existing geo-referenced data file consisting of latitude and longitude co-ordinates, location names and codes, herring sections, statistical areas and regions. A location code was entered for *all tag releases.* Codes for tag recoveries varied according to the precision of the return information. Several 'hierarchical levels were established: (1) the BC coast versus US waters; (2) the 'Region' or one 6 in BC: QCI (Queen Charlotte Islands), PRD (Prince Rupert District), (CC (Central coast), JS (Johnstone Strait), WCVI (West coast of Vancouver Island), SOG

Table 1. Continued. List of key names and variables in the revised, integrated herring tagging database.

(Strait of Georgia); (3) the Statistical Area, of which about 30 are precisely defined for the BC coast (Haist and Rosenfeld, 1988); (4) a 'Section' code (the Statistical area code plus another digit, for a total of about 100 different sections on the BC coast (Haist and Rosenfeld, 1988), (5) a location – there are about 1500 potential locations in BC (Haist and Rosenfeld, 1988).

For many returns, for example, we could identify the 'Region' of the recovery, but not necessarily the Statistical area. For others, we knew the Statistical area but not the location, and so on. For this reason, the number of tag returns varies as a function of the geographical scale of analyses. There are more tag recovery data available for analyses at the level of the Region than section or location. Recoveries designated as or "unknown" were entered into the database using the missing value code (9999).

AreaName: An alphanumeric name to describe the release or recovery location.

Geographic code: These codes facilitate the geographic partitioning of the data into 'Region', 'StatArea' and 'Section'. Numbers in these fields were obtained from a separate geo-referenced file with a location code linkage. *Figure 1 show maps of the 6 regions, 30 statistical areas and 108 sections currently in use.* New region codes were assigned for Washington State (7), Alaska (8) and USA (9) tag recoveries. Missing value codes (99 and 999) were entered for statistical areas and herring sections respectively.

Coordinates: Latitude and longitude co-ordinates that facilitates computerized mapping of all releases and recoveries and their linkages. Co-ordinates were entered manually for locations without location codes using the British Columbia Gazetteer (Canadian Permanent Committee on Geographical Names, 1985), Sailing Directions for the British Columbia Coast (Canada Dept. of Fisheries and Oceans and Canadian Hydrographic Service, 1990 and 1991), or from Canadian Hydrographic Service marine charts.

Table 2. The tagging years showing the numbers of different tagging 'capture and release' sessions per year (Release Sessions), the number of sessions that produced no subsequent tag returns, the total numbers of returned tags, the numbers of tags eventually recovered, and the recovery rate for all tags for the year of release.

Year	Release Sessions	Releases with no returns	Number of Tags Released	Number of Tags Recovered	Percent Recovery
1936	4	0	8590	53	0.5909
1937	15	0	15673	955	6.1839
1938	18	0	17436	469	2.6592
1939	25	2	24355	1243	4.8172
1940	29	4	29502	952	2.7126
1941	21	0	23870	462	1.8817
1942	19	5	23209	284	1.0928
1943	13	1	30131	629	1.8838
1944	15	4	47374	514	1.1930
1945	16	0	47579	926	1.8881
1946	18	0	51531	990	1.9479
1947	22	0	41551	2720	6.4912
1948	22	1	45577	2630	6.0600
1949	17	0	34874	1107	3.1236
1950	29	0	56435	3161	5.3797
1951	31	2	69106	4044	5.6596
1952	40	1	88820	1574	1.6425
1953	53	9	111693	3765	3.5183
1954	21	1	42465	3057	8.1131
1955	25	9	51711	1215	3.2286
1956	28	13	64978	1284	3.7368
1957	9	1	28258	258	3.6131
1958	1	0	10412	36	0.3458
1959	2	2	7664	0	0.0000
1964	18	0	33568	3771	11.3140
1965	8	0	11928	1198	8.1526
1966	4	0	482	29	11.1024
1967	3	3	4099	0	0.0000
1979	4	0	3554	33	1.1623
1980	68	23	75233	147	0.1890
1981	99	30	114099	783	0.5225
1982	37	3	72097	625	0.9244
1983	27	6	56748	243	0.5016
1985	7	1	8900	76	0.9278
1986	6	0	8969	300	2.4345
1988	10	0	10741	280	2.5589
1989	54	7	68844	602	1.5665
1990	71	8	96671	1550	1.9841
1991	46	10	56522	802	1.5259
All	**955**	**146**	**1595249**	**42767**	**2.6808**

Table 3. Summary of the numbers of releases shown by year and month.

Years	Unknown	January	February	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	All
1936	0	0	0	0	0	0	0	0	0	0	6290	2300	0	8590
1937	0	0	0	6392	1198	0	0	0	0	499	1957	5627	0	15673
1938	0	0	699	10666	1993	0	0	0	0	0	2532	99	1447	17436
1939	0	2945	0	19866	152	0	0	0	0	0	1195	197	0	24355
1940	0	0	1600	24210	2495	0	0	0	0	0	200	997	0	29502
1941	0	0	0	23374	0	0	0	0	0	0	496	0	0	23870
1942	0	0	1494	17026	2503	689	800	0	0	0	697	0	0	23209
1943	0	0	1892	21566	6673	0	0	0	0	0	0	0	0	30131
1944	0	0	8345	33577	4043	0	0	0	0	0	1409	0	0	47374
1945	0	0	1934	40431	5214	0	0	0	0	0	0	0	0	47579
1946	0	0	9029	40885	1617	0	0	0	0	0	0	0	0	51531
1947	0	0	6273	35278	0	0	0	0	0	0	0	0	0	41551
1948	0	0	6671	38906	0	0	0	0	0	0	0	0	0	45577
1949	0	0	5571	28299	1004	0	0	0	0	0	0	0	0	34874
1950	0	0	4048	46792	5595	0	0	0	0	0	0	0	0	56435
1951	0	0	6133	42561	8118	0	0	0	1400	6231	4663	0	0	69106
1952	0	0	3038	42556	15293	0	0	0	12168	13701	2064	0	0	88820
1953	2675	0	6147	71141	5121	0	0	0	19242	4108	3259	0	0	111693
1954	4000	0	2006	29393	2996	4070	0	0	0	0	0	0	0	42465
1955	0	1498	0	12977	9030	0	0	0	0	15015	5038	8153	0	51711
1956	10633	0	1249	11239	3047	0	0	0	0	30565	8245	0	0	64978
1957	19500	0	0	0	0	0	0	8016	503	239	0	0	0	28258
1958	0	0	0	10412	0	0	0	0	0	0	0	0	0	10412
1959	7664	0	0	0	0	0	0	0	0	0	0	0	0	7664
1964	0	0	0	12572	14996	0	0	6000	0	0	0	0	0	33568
1965	0	0	0	0	0	0	0	0	2000	9828	100	0	0	11928
1966	332	150	0	0	0	0	0	0	0	0	0	0	0	482
1967	0	0	0	0	0	0	992	3107	0	0	0	0	0	4099
1979	0	0	0	0	0	0	0	0	0	0	0	3554	0	3554
1980	0	978	0	41703	8212	0	0	0	0	10758	0	8617	4965	75233
1981	0	2958	0	64968	14878	1998	0	0	0	9641	0	9171	10485	114099
1982	0	1496	11636	20990	2677	0	2479	0	0	0	0	29844	2975	72097
1983	0	296	8828	9372	0	0	976	0	0	0	0	19596	17680	56748
1985	0	0	0	8900	0	0	0	0	0	0	0	0	0	8900
1986	0	0	0	6969	2000	0	0	0	0	0	0	0	0	8969
1988	0	0	0	10741	0	0	0	0	0	0	0	0	0	10741
1989	0	0	31429	37415	0	0	0	0	0	0	0	0	0	68844
1990	0	0	45130	50042	1499	0	0	0	0	0	0	0	0	96671
1991	0	0	13744	42278	500	0	0	0	0	0	0	0	0	56522
All	44804	10321	176896	913497	120854	6757	5247	17123	35313	100585	38145	88155	37552	1595249

Table 4. Total number of returns shown according to the numbers of years between release and recapture, for each release year. The second column, (0) indicates that less than 1 year transpired between release and recapture. The remaining columns show the number of recaptures in each year following the tag release. The column 'Total' shows all recoveries for each release year. In 1953 a strike by the fishing industry reduced catches to nearly zero. The effect of that low catch is seen as a low return of tags released in previous years. This effect is highlighted in ***bold Italics*** in the table. The period of anchor tags (1979-1991), shown in Italics, is separated by a space. Note that the total is lightly lower than Table 1, because the return years for some tags in unknown.

Years between release and recapture

Release Year	0	1	2	3	4	5	6	7	8	9	10	Total
1936	43	3	5	2	0	0	0	0	0	0	0	53
1937	152	770	29	1	1	0	0	0	0	0	0	953
1938	0	352	108	7	2	0	0	0	0	0	0	469
1939	570	540	112	19	2	0	0	0	0	0	0	1243
1940	65	664	161	39	20	2	1	0	0	0	0	952
1941	0	288	111	50	9	1	2	0	1	0	0	462
1942	0	112	130	16	23	0	2	1	0	0	0	284
1943	0	516	79	20	5	8	0	1	0	0	***0***	629
1944	0	352	75	45	23	11	4	1	1	***0***	2	514
1945	0	528	117	125	97	20	24	12	***0***	2	1	926
1946	0	564	295	102	16	5	7	***0***	0	1	0	990
1947	0	1779	766	129	26	20	***0***	0	0	0	0	2720
1948	0	2184	287	82	68	***0***	6	2	1	0	0	2630
1949	0	688	261	140	***0***	16	1	1	0	0	0	1107
1950	0	1919	1096	***0***	113	20	8	5	0	0	0	3161
1951	0	3401	***2***	525	55	38	19	0	1	3	0	4044
1952	1	***4***	1216	123	165	59	2	4	0	0	0	1574
1953	***1***	2687	409	497	154	3	12	2	0	0	0	3765
1954	0	1696	1109	211	4	31	2	4	0	0	0	3057
1955	0	879	305	24	7	0	0	0	0	0	0	1215
1956	218	945	91	25	5	0	0	0	0	0	0	1284
1957	0	68	108	22	24	0	0	0	0	0	0	222
1958	0	30	6	0	0	0	0	0	0	0	0	36
1959	0	0	0	0	0	0	0	0	0	0	0	0
1964	242	2310	911	307	0	0	0	0	0	0	0	3770
1965	0	1091	107	0	0	0	0	0	0	0	0	1198
1966	21	0	8	0	0	0	0	0	0	0	0	29
1967	0	0	0	0	0	0	0	0	0	0	0	0
1979	*29*	*4*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*33*
1980	*79*	*38*	*23*	*2*	*2*	*1*	*0*	*0*	*0*	*0*	*0*	*145*
1981	*622*	*135*	*14*	*8*	*3*	*0*	*0*	*0*	*0*	*0*	*0*	*782*
1982	*570*	*47*	*7*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*624*
1983	*234*	*9*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*243*
1985	*73*	*3*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*76*
1986	*300*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*300*
1988	*264*	*12*	*4*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*280*
1989	*505*	*71*	*26*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*602*
1990	*1402*	*141*	*7*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1550*
1991	*780*	*22*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*802*
All	**6171**	**24852**	**7985**	**2521**	**824**	**235**	**90**	**33**	**4**	**6**	**3**	**42724**

Table 5. Summary of the numbers of tags recovered after periods of 0 to 10 years at large. Data are shown for both tag types combined, and belly and anchor tags separately. The frequency is the number of tags recovered in one year as a proportion of the number of tags recovered in the previous year.

	All Tags		Belly Tags		Anchor Tags	
Years Free	Number Recovered	Frequency n_y/n_{y-1}	Number Recovered	Frequency n_y/n_{y-1}	Number Recovered	Frequency n_y/n_{y-1}
0	6209	-	1352	-	4857	-
1	24830	-	24348	-	482	(0.099)
2	7979	0.321	7898	0.324	81	0.168
3	2521	0.316	2511	0.324	10	0.123
4	823	0.326	818	0.326	5	
5	235	0.286	234	0.286	1	
6	90	0.383	90	0.385		
7	33	0.367	33	0.367		
8	4		4			
9	6		6			
10	3		3			
Totals	42733		37297		5436	

Table 6a. Summary of the number of tag returns by month according to the year of release. The column 'unknown' indicates that the month of recovery was not known.

Year	Unknown	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	All
1936	7	0	0	0	0	0	0	0	0	0	0	46	0	53
1937	798	0	0	0	0	0	0	0	0	0	24	123	10	955
1938	425	42	0	0	1	0	0	0	0	0	1	0	0	469
1939	1243	0	0	0	0	0	0	0	0	0	0	0	0	1243
1940	952	0	0	0	0	0	0	0	0	0	0	0	0	952
1941	462	0	0	0	0	0	0	0	0	0	0	0	0	462
1942	284	0	0	0	0	0	0	0	0	0	0	0	0	284
1943	629	0	0	0	0	0	0	0	0	0	0	0	0	629
1944	514	0	0	0	0	0	0	0	0	0	0	0	0	514
1945	926	0	0	0	0	0	0	0	0	0	0	0	0	926
1946	990	0	0	0	0	0	0	0	0	0	0	0	0	990
1947	2720	0	0	0	0	0	0	0	0	0	0	0	0	2720
1948	2630	0	0	0	0	0	0	0	0	0	0	0	0	2630
1949	1107	0	0	0	0	0	0	0	0	0	0	0	0	1107
1950	3161	0	0	0	0	0	0	0	0	0	0	0	0	3161
1951	4042	0	1	0	0	0	0	0	0	0	0	0	1	4044
1952	1526	5	0	1	0	0	0	0	1	0	5	12	24	1574
1953	3762	0	0	0	0	0	0	0	0	0	1	0	2	3765
1954	3057	0	0	0	0	0	0	0	0	0	0	0	0	3057
1955	1215	0	0	0	0	0	0	0	0	0	0	0	0	1215
1956	1284	0	0	0	0	0	0	0	0	0	0	0	0	1284
1957	258	0	0	0	0	0	0	0	0	0	0	0	0	258
1958	36	0	0	0	0	0	0	0	0	0	0	0	0	36
1964	3771	0	0	0	0	0	0	0	0	0	0	0	0	3771
1965	1198	0	0	0	0	0	0	0	0	0	0	0	0	1198
1966	29	0	0	0	0	0	0	0	0	0	0	0	0	29
1979	0	1	0	3	1	1	1	0	0	0	0	23	3	33
1980	2	3	3	66	15	10	4	4	1	3	0	16	20	147
1981	1	24	13	338	50	6	1	2	2	3	0	327	16	783
1982	1	33	35	460	5	0	1	3	0	0	0	46	41	625
1983	0	35	13	182	0	0	0	4	1	0	0	2	6	243
1985	0	0	0	76	0	0	0	0	0	0	0	0	0	76
1986	0	0	0	11	287	0	2	0	0	0	0	0	0	300
1988	0	0	0	4	276	0	0	0	0	0	0	0	0	280
1989	8	0	0	561	24	0	8	0	0	0	0	1	0	602
1990	1	0	0	1321	226	1	1	0	0	0	0	0	0	1550
1991	0	0	0	685	117	0	0	0	0	0	0	0	0	802
All	**37039**	**143**	**65**	**3708**	**1002**	**18**	**18**	**13**	**5**	**6**	**31**	**596**	**123**	**42767**

Table 6b. Summary of the number of tag returns by month according to the year of release. All tags had been at large for 1 year or longer.

Year	Unknown	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	All
1936	7	0	0	0	0	0	0	0	0	0	3	0		10
1937	62	0	0	0	0	0	0	0	0	0	3	1		66
1938	206	0	0	0	1	0	0	0	0	0	0	0		207
1939	657	0	0	0	0	0	0	0	0	0	0	0		657
1940	887	0	0	0	0	0	0	0	0	0	0	0		887
1941	453	0	0	0	0	0	0	0	0	0	0	0		453
1942	265	0	0	0	0	0	0	0	0	0	0	0		265
1943	629	0	0	0	0	0	0	0	0	0	0	0		629
1944	438	0	0	0	0	0	0	0	0	0	0	0		438
1945	926	0	0	0	0	0	0	0	0	0	0	0		926
1946	990	0	0	0	0	0	0	0	0	0	0	0		990
1947	2720	0	0	0	0	0	0	0	0	0	0	0		2720
1948	2630	0	0	0	0	0	0	0	0	0	0	0		2630
1949	1107	0	0	0	0	0	0	0	0	0	0	0		1107
1950	3161	0	0	0	0	0	0	0	0	0	0	0		3161
1951	3986	0	1	0	0	0	0	0	0	0	0	1		3988
1952	1526	5	0	1	0	0	0	0	0	5	12	24		1573
1953	3762	0	0	0	0	0	0	0	0	0	0	2		3764
1954	3057	0	0	0	0	0	0	0	0	0	0	0		3057
1955	1215	0	0	0	0	0	0	0	0	0	0	0		1215
1956	1042	0	0	0	0	0	0	0	0	0	0	0		1042
1957	154	0	0	0	0	0	0	0	0	0	0	0		154
1958	36	0	0	0	0	0	0	0	0	0	0	0		36
1964	3278	0	0	0	0	0	0	0	0	0	0	0		3278
1965	107	0	0	0	0	0	0	0	0	0	0	0		107
1966	8	0	0	0	0	0	0	0	0	0	0	0		8
1979	0	0	0	3	0	0	0	0	0	0	0	0		3
1980	0	0	2	32	0	1	1	1	1	0	6	0		44
1981	0	1	12	70	0	0	0	0	1	0	1	8		93
1982	0	1	1	45	0	0	0	0	0	0	0	0		47
1983	0	0	0	8	0	0	0	0	0	0	0	0		8
1985	0	0	0	3	0	0	0	0	0	0	0	0		3
1988	0	0	0	2	13	0	0	0	0	0	0	0		15
1989	0	0	0	93	3	0	0	0	0	0	0	0		96
1990	1	0	0	132	11	0	0	0	0	0	0	0		144
1991	0	0	0	21	1	0	0	0	0	0	0	0		22
ALL	33310	7	16	410	29	1	1	1	2	5	25	36		33843

Table 7. The numbers of recaptures by region (columns) shown by the region of release (rows). The recovery region of a total of 8,311 recovered tags shown under column (UNK) could not be assigned to a single region. Region USA1 and USA2 refer to Washington State and Alaska, respectively. Region USA3, refers only to recoveries from US waters, but not necessarily Washington or Alaska. This table shows the recovery of all tags, regardless of the time at large. An example of an interpretation of these numbers is as follows: 3,903 tags were recovered from tags released in Region 1. Of these, the recovery location (Region) of 747 could not be determined for 747 tags, 2,885 were recovered in Region1, 146 in region 2, and so on. Table 7a shows recoveries for all tags for all times at large; table 7b shows recoveries only for tags at large for 1 year or more.

(a) Recovery – at large 0-10 years

		Regions										
		UNK	**QCI**	**PRD**	**CC**	**JS**	**SOG**	**WCVI**	**USA1**	**USA2**	**USA3**	**All**
R	1	747	2885	146	104	0	9	12	0	0	0	3903
e	2	679	204	3098	220	18	15	11	0	3	0	4248
l	3	1767	118	551	8249	52	37	80	0	1	0	10855
e	4	536	0	4	369	801	142	22	0	0	0	1874
a	5	2922	7	12	64	282	3494	287	4	0	0	7072
s	6	1644	26	16	175	18	458	12398	2	0	8	14745
e	7	16	0	0	0	0	45	9	0	0	0	70
	All	8311	3240	3827	9181	1171	4200	12819	6	4	8	42767

(b) Recovery – at large 1-10 years

		UNK	**QCI**	**PRD**	**CC**	**JS**	**SOG**	**WCVI**	**USA1**	**USA2**	**USA3**	**All**
R	1	684	2243	91	67	0	3	4	0	0	0	3092
e	2	673	149	1876	176	14	12	5	0	1	0	2906
l	3	1689	92	435	7233	34	26	48	0	0	0	9557
e	4	529	0	1	368	711	63	16	0	0	0	1688
a	5	2588	0	5	45	275	1864	202	0	0	0	4979
s	6	1483	8	9	96	18	284	9680	1	0	0	11579
e	7	16	0	0	0	0	22	4	0	0	0	42
	All	7662	2492	2417	7985	1052	2274	9959	1	1	0	33843

Table 8a. The number and percentage of recoveries and releases for each Region. For each region, the data are presented in three rows. The top row indicates the numbers recovered in each region and total number released in the region (under 'All'). The second row ('%F') shows the same information as a percentage: the number recovered relative to the numbers RELEASED IN THE REGION, and this always sums to 100% in the column on the far right. The third row (%I, and shown in *Italics*) indicates the number of tags recovered in the region as a percentage of tags RELEASED IN ALL REGIONS, and this always sums to 100% in the bottom row for each column under 'Recovery'. Tags recovered in the same area of release are shown in bold. For example, 3156 tags were **released** in the QCI (top row under release (QCI). Of these, 2885 (or 91.41%) were recovered in the QCI. On the other hand 3240 tags were **recovered** in the QCI (see bottom row under Recovery for 'QCI'. Of these 2885 (or 89.04%) were released in the QCI.

		Recovery						
		QCI	PRD	CC	JS	SOG	WCVI	All
Release	QCI	**2885**	146	104	0	9	12	3156
	% F	**91.41**	4.63	3.30	--	0.29	0.38	100.00
	% I	***89.04***	*3.81*	*1.13*	--	*0.22*	*0.09*	*9.18*
	PRD	204	**3098**	220	18	15	11	3566
	% F	5.72	**86.88**	6.17	0.50	0.42	0.31	100.00
	% I	*6.30*	***80.95***	*2.40*	*1.54*	*0.36*	*0.09*	*10.37*
	CC	118	551	**8249**	52	37	80	9087
	% F	1.30	6.06	**90.78**	0.57	0.41	0.88	100.00
	% I	3.64	14.40	**89.85**	4.44	0.89	0.62	26.43
	JS	0	4	369	**801**	142	22	1338
	% F	--	0.30	27.58	**59.87**	10.61	1.64	100.00
	% I	--	*0.10*	*4.02*	***68.40***	*3.42*	*0.17*	*3.89*
	SOG	7	12	64	282	**3494**	287	4146
	% F	0.17	0.29	1.54	6.80	**84.27**	6.92	100.00
	% I	*0.22*	*0.31*	*0.70*	*24.08*	***84.09***	*2.24*	*12.06*
	WCVI	26	16	175	18	458	**12398**	13091
	% F	0.20	0.12	1.34	0.14	3.50	**94.71**	100.00
	% I	0.80	0.42	1.91	1.54	11.02	**96.78**	38.07
	All	3240	3827	9181	1171	4155	12810	34384
	% F	9.42	11.13	26.70	3.41	12.08	37.26	100.00
	% I	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 8b. The number and percentage of recoveries and releases for each Region - ***based on herring that have been at large for 1 year or longer***. For each region, the data are presented in three rows. The top row indicates the numbers recovered in each region and total number released in the region (under 'All'). The second row ('%F') shows the same information as a percentage: the number recovered relative to the numbers RELEASED IN THE REGION, and this always sums to 100% in the column on the far right. The third row (%I, and shown in *Italics*) indicates the number of tags recovered in the region as a percentage of tags RELEASED IN ALL REGIONS, and this always sums to 100% in the bottom row for each column under 'Recovery'. Tags recovered in the same area of release are shown in bold. For example, 2384 tags were **released** in the QCI (top row under release (QCI). Of these, 2197 (or 92.16%) were recovered in the QCI. On the other hand 2361 tags were **recovered** in the QCI (see bottom row under Recovery for 'QCI'. Of these 2197 (or 93.05%) were released in the QCI.

		Recovery						
		QCI	**PRD**	**CC**	**JS**	**SOG**	**WCVI**	**All**
	QCI	**2197**	108	60	0	8	11	2384
	% F	**92.16**	4.53	2.52	--	0.34	0.46	100.00
	% I	**93.05**	3.50	0.99	--	0.23	0.11	9.37
	PRD	69	**2508**	154	9	10	9	2759
R	**% F**	2.50	**90.90**	5.58	0.33	0.36	0.33	100.00
e	**% I**	2.92	**81.38**	2.55	1.23	0.28	0.09	10.84
l								
e	**CC**	67	444	**5308**	43	24	64	5950
a	**% F**	1.13	7.46	**89.21**	0.72	0.40	1.08	100.00
s	**% I**	2.84	14.41	**87.90**	5.90	0.68	0.66	23.38
e								
	JS	0	3	329	**519**	112	12	975
	% F	--	0.31	33.74	**53.23**	11.49	1.23	100.00
	% I	--	0.10	5.45	**71.19**	3.16	0.12	3.83
	SOG	7	10	47	150	**3042**	227	3483
	% F	0.20	0.29	1.35	4.31	**87.34**	6.52	100.00
	% I	0.30	0.32	0.78	20.58	**85.71**	2.34	13.68
	WCVI	21	9	141	8	353	**9369**	9901
	% F	0.21	0.09	1.42	0.08	3.57	**94.63**	100.00
	% I	0.89	0.29	2.33	1.10	9.95	**96.67**	38.90
	All	2361	3082	6039	729	3549	9692	25452
	% F	9.28	12.11	23.73	2.86	13.94	38.08	100.00
	% I	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 9a. *Numbers* of tags recovered and released by Statistical Area (Stat) and at large for 1 or more years. Rows show the Statistical Area of release. Columns show the Statistical Area of recovery. The numbers of tags recovered in the same Statistical area as the release, is highlighted. The recoveries in Statistical Area 21 is highlighted as an example of a high recovery rate to a non-spawning area.

		RECOVERY													
		STAT 0	STAT 1	STAT 2	STAT 3	STAT 4	STAT 5	STAT 6	STAT 7	STAT 8	STAT 9	STAT 10	STAT 12	STAT 13	STAT 14
	0	*407*	0	286	1	1	11	1	21	0	0	0	0	0	1
	1	1	*0*	2	4	0	36	1	0	0	0	0	0	0	0
	2	20	36	*467*	3	1	8	2	28	0	0	0	0	0	2
	3	0	0	0	*5*	4	10	0	2	0	0	0	0	0	0
	4	0	0	26	29	*53*	47	13	1	0	0	0	0	8	0
	5	0	1	9	0	3	*70*	81	0	0	0	0	0	0	0
	6	2	1	37	0	7	11	*545*	49	9	1	0	0	1	0
R	7	4	1	4	0	0	5	232	*568*	466	3	2	7	1	1
E	8	2	0	1	0	0	0	4	293	*25*	0	0	1	0	0
L	9	0	0	0	0	0	0	2	1	1	*1*	1	0	0	0
E	10	0	0	0	0	0	0	2	17	0	0	*15*	4	4	0
A	12	0	0	0	1	0	0	9	0	310	3	0	*463*	27	4
S	13	0	0	0	0	0	0	2	0	31	0	0	24	84	13
E	14	0	0	0	0	0	0	1	3	3	0	0	1	89	39
	15	0	0	0	0	0	0	2	5	7	1	0	5	131	32
	16	0	0	0	0	0	0	0	0	0	0	0	0	14	63
	17	0	0	0	1	0	0	0	1	3	0	0	1	23	36
	18	0	0	0	0	0	0	0	0	0	0	0	1	2	12
	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	20	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	21	0	0	0	0	0	0	0	0	0	0	0	0	0	4
	23	1	0	2	0	0	0	1	3	0	0	0	0	5	5
	24	1	0	1	0	0	1	1	1	0	0	0	0	1	0
	25	0	0	0	0	0	0	0	3	1	0	0	5	1	1
	26	0	0	0	0	0	0	0	4	1	0	0	0	0	0
	27	0	0	0	0	0	0	1	9	6	0	0	0	0	0
	All	438	39	835	44	69	199	900	1009	863	9	18	512	392	214

Table 9a. Continued. *Numbers* of tags recovered and released by Statistical Area (Stat) and at large for 1 or more years. Rows show the Statistical Area of release. Columns show the Statistical Area of recovery. The numbers of tags recovered in the same Statistical area as the release, is highlighted. The recoveries in Statistical Area 21 is highlighted as an example of a high recovery rate to a non-spawning area.

		RECOVERY												
		STAT 15	STAT 17	STAT 18	STAT 19	STAT 20	STAT 21	STAT 23	STAT 24	STAT 25	STAT 26	STAT 27	STAT 28	All
	0	0	0	0	0	0	0	1	0	0	0	0	0	730
	1	0	0	0	0	0	0	0	0	0	0	0	0	44
	2	0	0	0	0	0	0	1	0	0	0	0	0	568
	3	0	0	0	0	0	0	1	0	0	0	0	0	22
	4	0	0	2	0	0	0	1	0	0	0	0	0	180
	5	0	0	0	0	0	0	0	0	1	0	0	0	165
	6	0	0	2	0	0	0	1	0	1	0	0	0	667
R	7	0	3	0	0	0	0	7	0	5	3	3	0	1315
E	8	0	0	0	0	0	0	0	0	1	2	2	0	331
L	9	0	0	0	0	0	0	0	0	0	0	0	0	6
E	10	0	0	0	0	0	0	0	0	0	0	0	0	42
A	12	0	1	2	0	0	0	2	1	2	1	0	0	826
S	13	4	12	5	0	0	0	1	0	1	0	0	0	177
E	14	0	33	38	0	0	0	7	0	3	1	1	1	220
	15	1	31	4	0	0	0	1	1	0	0	0	0	221
	16	0	28	6	0	0	0	2	0	2	0	0	0	115
	17	3	**139**	312	3	0	2	33	0	2	0	0	2	561
	18	0	49	**118**	0	0	0	31	1	0	0	1	0	215
	19	0	0	4	**0**	0	0	14	3	0	1	0	0	22
	20	0	23	119	0	1	0	16	0	1	1	0	0	163
	21	0	10	0	0	0	***799**	8	1	3	0	0	0	825
	23	0	72	44	0	0	0	**2305**	3	123	10	2	0	2576
	24	0	14	11	2	0	0	370	**67**	248	15	0	0	733
	25	1	5	7	0	0	0	146	17	**701**	61	6	0	955
	26	0	0	0	0	0	0	24	7	261	**115**	1	0	413
	27	0	2	1	0	0	0	11	**4**	76	56	**65**	0	231
	All	9	422	675	5	1	801	2983	105	1431	266	81	3	12323

Table 9b. Percentage of recovered tags shown according to the Statistical Area (Stat) of *release* and at large for 1 or more years. Rows show the Statistical Area of release. Columns show the Statistical Area of recovery. The numbers of tags recovered in the same Statistical area as the release, is highlighted. The recoveries in Statistical Area 21 is highlighted as an example of a high recovery rate to a non-spawning area.

		RECOVERY													
		STAT 0	STAT 1	STAT 2	STAT 3	STAT 4	STAT 5	STAT 6	STAT 7	STAT 8	STAT 9	STAT 10	STAT 12	STAT 13	STAT 14
	0	55.75	--	39.18	0.14	0.14	1.51	0.14	2.88	--	--	--	--	--	0.14
	1	2.27	--	4.55	9.09	--	81.82	2.27	--	--	--	--	--	--	--
	2	3.52	6.34	82.22	0.53	0.18	1.41	0.35	4.93	--	--	--	--	--	0.35
	3	--	--	--	22.73	18.18	45.45	--	9.09	--	--	--	--	--	--
	4	--	--	14.44	16.11	29.44	26.11	7.22	0.56	--	--	--	--	4.44	--
	5	--	0.61	5.45	--	1.82	42.42	49.09	--	--	--	--	--	--	--
	6	0.30	0.15	5.55	--	1.05	1.65	81.71	7.35	1.35	0.15	--	--	0.15	--
R	7	0.30	0.08	0.30	--	--	0.38	17.64	43.19	35.44	0.23	0.15	0.53	0.08	0.08
E	8	0.60	--	0.30	--	--	--	1.21	88.52	7.55	--	--	0.30	--	--
L	9	--	--	--	--	--	--	33.33	16.67	16.67	16.67	16.67	--	--	--
E	10	--	--	--	--	--	--	4.76	40.48	--	--	35.71	9.52	9.52	--
A	12	--	--	--	0.12	--	--	1.09	--	37.53	0.36	--	56.05	3.27	0.48
S	13	--	--	--	--	--	--	1.13	--	17.51	--	--	13.56	47.46	7.34
E	14	--	--	--	--	--	--	0.45	1.36	1.36	--	--	0.45	40.45	17.73
	15	--	--	--	--	--	--	0.90	2.26	3.17	0.45	--	2.26	59.28	14.48
	16	--	--	--	--	--	--	--	--	--	--	--	--	12.17	54.78
	17	--	--	--	0.18	--	--	--	0.18	0.53	--	--	0.18	4.10	6.42
	18	--	--	--	--	--	--	--	--	--	--	--	0.47	0.93	5.58
	19	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	20	--	--	--	--	--	--	--	--	--	--	--	--	0.61	0.61
	21	--	--	--	--	--	--	--	--	--	--	--	--	--	0.48
	23	0.04	--	0.08	--	--	--	0.04	0.12	--	--	--	--	0.19	0.19
	24	0.14	--	0.14	--	--	0.14	0.14	0.14	--	--	--	--	0.14	--
	25	--	--	--	--	--	--	--	0.31	0.10	--	--	0.52	0.10	0.10
	26	--	--	--	--	--	--	--	0.97	0.24	--	--	--	--	--
	27	--	--	--	--	--	--	0.43	3.90	2.60	--	--	--	--	--
	All	3.55	0.32	6.78	0.36	0.56	1.61	7.30	8.19	7.00	0.07	0.15	4.15	3.18	1.74

Table 9b. Continued. Percentage of recovered tags shown according to the Statistical Area (Stat) of *release* and at large for 1 or more years. Rows show the Statistical Area of release. Columns show the Statistical Area of recovery. The numbers of tags recovered in the same Statistical area as the release, is highlighted. The recoveries in Statistical Area 21 is highlighted as an example of a high recovery rate to a non-spawning area.

		RECOVERY												
		STAT 15	STAT 17	STAT 18	STAT 19	STAT 20	STAT 21	STAT 23	STAT 24	STAT 25	STAT 26	STAT 27	STAT 28	All
	0	--	--	--	--	--	--	0.14	--	--	--	--	--	100.00
	1	--	--	--	--	--	--	--	--	--	--	--	--	100.00
	2	--	--	--	--	--	--	0.18	--	--	--	--	--	100.00
	3	--	--	--	--	--	--	4.55	--	--	--	--	--	100.00
	4	--	--	1.11	--	--	--	0.56	--	--	--	--	--	100.00
	5	--	--	--	--	--	--	--	--	0.61	--	--	--	100.00
	6	--	--	0.30	--	--	--	0.15	--	0.15	--	--	--	100.00
R	7	--	0.23	--	--	--	--	0.53	--	0.38	0.23	0.23	--	100.00
E	8	--	--	--	--	--	--	--	--	0.30	0.60	0.60	--	100.00
L	9	--	--	--	--	--	--	--	--	--	--	--	--	100.00
E	10	--	--	--	--	--	--	--	--	--	--	--	--	100.00
A	12	--	0.12	0.24	--	--	--	0.24	0.12	0.24	0.12	--	--	100.00
S	13	2.26	6.78	2.82	--	--	--	0.56	--	0.56	--	--	--	100.00
E	14	--	15.00	17.27	--	--	--	3.18	--	1.36	0.45	0.45	0.45	100.00
	15	0.45	14.03	1.81	--	--	--	0.45	0.45	--	--	--	--	100.00
	16	--	24.35	5.22	--	--	--	1.74	--	1.74	--	--	--	100.00
	17	0.53	**24.78**	55.61	0.53	--	0.36	5.88	--	0.36	--	--	0.36	100.00
	18	--	22.79	**54.88**	--	--	--	14.42	0.47	--	--	0.47	--	100.00
	19	--	--	18.18	--	--	--	63.64	13.64	--	4.55	--	--	100.00
	20	--	14.11	73.01	--	0.61	--	9.82	--	0.61	0.61	--	--	100.00
	21	--	1.21	--	--	--	**96.85***	0.97	0.12	0.36	--	--	--	100.00
	23	--	2.80	1.71	--	--	--	**89.48**	0.12	4.77	0.39	0.08	--	100.00
	24	--	1.91	1.50	0.27	--	--	50.48	**9.14**	33.83	2.05	--	--	100.00
	25	0.10	0.52	0.73	--	--	--	15.29	1.78	**73.40**	6.39	0.63	--	100.00
	26	--	--	--	--	--	--	5.81	1.69	63.20	**27.85**	0.24	--	100.00
	27	--	0.87	0.43	--	--	--	4.76	1.73	32.90	24.24	**28.14**	--	100.00
	All	0.07	3.42	5.48	0.04	0.01	6.50	24.21	0.85	11.61	2.16	0.66	0.02	100.00

Table 9c. Percentage of recovered tags shown according to the Statistical Area (Stat) of *recovery* and at large for 1 or more years. Rows show the Statistical Area of release. Columns show the Statistical Area of recovery. The numbers of tags recovered in the same Statistical area as the release, is highlighted. The recoveries in Statistical Area 21 is highlighted as an example of a high recovery rate to a non-spawning area.

		RECOVERY													
		STAT 0	STAT 1	STAT 2	STAT 3	STAT 4	STAT 5	STAT 6	STAT 7	STAT 8	STAT 9	STAT 10	STAT 12	STAT 13	STAT 14
	0	**92.92**	--	34.25	2.27	1.45	5.53	0.11	2.08	--	--	--	--	--	0.47
	1	0.23	--	0.24	9.09	--	18.09	0.11	--	--	--	--	--	--	--
	2	4.57	92.31	**55.93**	6.82	1.45	4.02	0.22	2.78	--	--	--	--	--	0.93
	3	--	--	--	11.36	5.80	5.03	--	0.20	--	--	--	--	--	--
	4	--	--	3.11	65.91	**76.81**	23.62	1.44	0.10	--	--	--	--	2.04	--
	5	--	2.56	1.08	--	4.35	**35.18**	9.00	--	--	--	--	--	--	--
	6	0.46	2.56	4.43	--	10.14	5.53	**60.56**	4.86	1.04	11.11	--	--	0.26	--
R	7	0.91	2.56	0.48	--	--	2.51	25.78	**56.29**	54.00	33.33	11.11	1.37	0.26	0.47
E	8	0.46	--	0.12	--	--	--	0.44	29.04	**2.90**	--	--	0.20	--	--
L	9	--	--	--	--	--	--	0.22	0.10	0.12	11.11	5.56	--	--	--
E	10	--	--	--	--	--	--	0.22	1.68	--	--	**83.33**	0.78	1.02	--
A	12	--	--	--	2.27	--	--	1.00	--	35.92	33.33	--	**90.43**	6.89	1.87
S	13	--	--	--	--	--	--	0.22	--	3.59	--	--	4.69	**21.43**	6.07
E	14	--	--	--	--	--	--	0.11	0.30	0.35	--	--	0.20	22.70	**18.22**
	15	--	--	--	--	--	--	0.22	0.50	0.81	11.11	--	0.98	33.42	14.95
	16	--	--	--	--	--	--	--	--	--	--	--	--	3.57	29.44
	17	--	--	--	2.27	--	--	--	0.10	0.35	--	--	0.20	5.87	16.82
	18	--	--	--	--	--	--	--	--	--	--	--	0.20	0.51	5.61
	19	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	20	--	--	--	--	--	--	--	--	--	--	--	--	0.26	0.47
	21	--	--	--	--	--	--	--	--	--	--	--	--	--	1.87
	23	0.23	--	0.24	--	--	--	0.11	0.30	--	--	--	--	1.28	2.34
	24	0.23	--	0.12	--	--	0.50	0.11	0.10	--	--	--	--	0.26	--
	25	--	--	--	--	--	--	--	0.30	0.12	--	--	0.98	0.26	0.47
	26	--	--	--	--	--	--	--	0.40	0.12	--	--	--	--	--
	27	--	--	--	--	--	--	0.11	0.89	0.70	--	--	--	--	--
	All	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 9c. Continued. Percentage of recovered tags shown according to the Statistical Area (Stat) of *recovery* and at large for 1 or more years. Rows show the Statistical Area of release. Columns show the Statistical Area of recovery. The numbers of tags recovered in the same Statistical area as the release, is highlighted. The recoveries in Statistical Area 21 is highlighted as an example of a high recovery rate to a non-spawning area.

		RECOVERY												
		STAT 15	STAT 17	STAT 18	STAT 19	STAT 20	STAT 21	STAT 23	STAT 24	STAT 25	STAT 26	STAT 27	STAT 28	All
	0	--	--	--	--	--	--	0.03	--	--	--	--	--	5.92
	1	--	--	--	--	--	--	--	--	--	--	--	--	0.36
	2	--	--	--	--	--	--	0.03	--	--	--	--	--	4.61
	3	--	--	--	--	--	--	0.03	--	--	--	--	--	0.18
	4	--	--	0.30	--	--	--	0.03	--	--	--	--	--	1.46
	5	--	--	--	--	--	--	--	--	0.07	--	--	--	1.34
	6	--	--	0.30	--	--	--	0.03	--	0.07	--	--	--	5.41
R	7	--	0.71	--	--	--	--	0.23	--	0.35	1.13	3.70	--	10.67
E	8	--	--	--	--	--	--	--	--	0.07	0.75	2.47	--	2.69
L	9	--	--	--	--	--	--	--	--	--	--	--	--	0.05
E	10	--	--	--	--	--	--	--	--	--	--	--	--	0.34
A	12	--	0.24	0.30	--	--	--	0.07	0.95	0.14	0.38	--	--	6.70
S	13	44.44	2.84	0.74	--	--	--	0.03	--	0.07	--	--	--	1.44
E	14	--	7.82	5.63	--	--	--	0.23	--	0.21	0.38	1.23	33.33	1.79
	15	**11.11**	7.35	0.59	--	--	--	0.03	0.95	--	--	--	--	1.79
	16	--	6.64	0.89	--	--	--	0.07	--	0.14	--	--	--	0.93
	17	33.33	**32.94**	46.22	60.00	--	0.25	1.11	--	0.14	--	--	66.67	4.55
	18	--	11.61	17.48	--	--	--	1.04	0.95	--	--	1.23	--	1.74
	19	--	--	0.59	--	--	--	0.47	2.86	--	0.38	--	--	0.18
	20	--	5.45	17.63	--	100.00	--	0.54	--	0.07	0.38	--	--	1.32
	21	--	2.37	--	--	--	***99.75**	0.27	0.95	0.21	--	--	--	6.69
	23	--	17.06	6.52	--	--	--	**77.27**	2.86	8.60	3.76	2.47	--	20.90
	24	--	3.32	1.63	40.00	--	--	12.40	**63.81**	17.33	5.64	--	--	5.95
	25	11.11	1.18	1.04	--	--	--	4.89	16.19	**48.99**	22.93	7.41	--	7.75
	26	--	--	--	--	--	--	0.80	6.67	18.24	**43.23**	1.23	--	3.35
	27	--	0.47	0.15	--	--	--	0.37	3.81	5.31	21.05	**80.25**	--	1.87
	All	00.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 10a. Geographic fidelity estimates for Regions, shown in bold Italics, and numbers of recovered tags shown by the numbers of years at large (years between release and recapture). Tag returns at large for 6 or more years 6 were pooled in the 6-year column.

	Years at large							
	0	1	2	3	4	5	6	All
Region								
QCI	540	1843	390	257	97	24	4	3155
	0.8907	***0.9311***	***0.9436***	***0.8132***	***0.9072***	***0.8750***	***0.5000***	***0.9144***
PRD	1313	1446	522	228	44	3	10	3566
	0.9193	***0.8997***	***0.7261***	***0.7632***	***0.6818***	***0.6667***	***0.5000***	***0.8688***
CC	1114	4836	2113	738	201	60	25	9087
	0.8205	***0.9086***	***0.9569***	***0.9133***	***0.8607***	***0.8833***	***0.7600***	***0.9078***
JS	177	798	240	57	48	5	13	1338
	0.5028	***0.5388***	***0.7667***	***0.6667***	***0.9167***	***0.8000***	***0.9231***	***0.5987***
SOG	1473	1987	486	132	30	10	5	4123
	0.9375	***0.8244***	***0.6934***	***0.6212***	***0.7667***	***0.9000***	***0.2000***	***0.8419***
WCVI	1357	8542	2446	520	145	48	31	13089
	0.8946	***0.9545***	***0.9505***	***0.9462***	***0.9448***	***0.9792***	***0.9032***	***0.9471***
All	5974	19452	6197	1932	565	150	88	34358
	0.8848	***0.9064***	***0.9061***	***0.8639***	***0.8761***	***0.9067***	***0.7614***	***0.8994***

Table 10b. Geographic fidelity estimates for Statistical Areas (SA), shown in bold Italics, and numbers of recovered tags shown by the numbers of years at large (years between release and recapture). Tag returns at large for 6 or more years 6 were pooled in the 6-year column.

	Years at large							
	0	1	2	3	4	5	6	All
SA								
0	457	383	55	0	0	0	0	895
	0.8665	***0.9399***	***0.8545***	--	--	--	--	***0.8972***
1	1	0	19	19	1	0	0	40
	0.0000	--	***0.0000***	***0.0000***	***0.0000***	--	--	***0.0000***
2	124	778	40	3	1	11	2	959
	0.5484	***0.5758***	***0.0750***	***0.6667***	***1.0000***	***1.0000***	***1.0000***	***0.5579***
3	***195***	***33***	***11***	***0***	***0***	***0***	***0***	***239***
	0.5077	***0.0909***	***0.1818***	--	--	--	--	***0.4351***
4	312	50	0	7	10	0	2	381
	0.5865	***0.9000***	--	***0.5714***	***0.4000***	--	***0.0000***	***0.6194***
5	821	168	24	5	2	0	0	1020
	0.8514	***0.3095***	***0.6250***	***0.6000***	***0.0000***	--	--	***0.7539***
6	333	695	186	8	9	1	1	1233
	0.7508	***0.6619***	***0.4140***	***0.1250***	***0.5556***	***1.0000***	***1.0000***	***0.6448***
7	533	681	25	283	17	3	0	1542
	0.6998	***0.7078***	***0.5200***	***0.2261***	***0.3529***	***1.0000***	--	***0.6102***
8	189	718	93	42	10	0	0	1052
	0.7090	***0.0153***	***0.0000***	***0.3333***	***0.0000***	--	--	***0.1511***
9	0	7	0	0	1	1	0	9
	--	***0.0000***	--	--	***1.0000***	***0.0000***	--	***0.1111***
10	0	1	0	17	0	0	0	18
	--	***0.0000***	--	***0.8824***	--	--	--	***0.8333***
12	26	300	144	31	28	4	5	538
	0.1538	***0.8900***	***0.9306***	***0.8710***	***0.9286***	***1.0000***	***1.0000***	***0.8680***
13	85	204	135	41	9	1	2	477
	0.9765	***0.2255***	***0.2222***	***0.1707***	***0.1111***	***0.0000***	***0.0000***	***0.3501***
14	272	134	67	9	3	1	0	486
	0.3088	***0.1940***	***0.1940***	***0.0000***	***0.0000***	***0.0000***	--	***0.2531***
15	86	6	2	0	0	1	0	95
	0.1047	***0.0000***	***0.0000***	--	--	***1.0000***	--	***0.1053***

Table 10b. Continued. Geographic fidelity estimates for Statistical Areas (SA), shown in bold Italics, and numbers of recovered tags shown by the numbers of years at large (years between release and recapture). Tag returns at large for 6 or more years 6 were pooled in the 6-year column.

	Years at large							
	0	1	2	3	4	5	6	All
SA								
16	6	0	0	0	0	0	0	6
	0.8333	--	--	--	--	--	--	***0.8333***
17	747	320	83	12	5	2	0	1169
	0.9719	***0.3875***	***0.1566***	***0.1667***	***0.0000***	***0.0000***	--	***0.7399***
18	120	549	100	24	1	0	1	795
	0.6917	***0.1821***	***0.0900***	***0.3333***	***0.0000***	--	***1.0000***	***0.2528***
19	4	4	1	0	0	0	0	9
	0.0000	***0.0000***	***0.0000***	--	--	--	--	***0.0000***
20	1	1	0	0	0	0	0	2
	0.0000	***1.0000***	--	--	--	--	--	***0.5000***
21	3	766	35	0	0	0	0	804
	0.3333	***0.9974***	***1.0000***	--	--	--	--	***0.9950***
23	738	2609	279	82	11	1	1	3721
	0.8780	***0.7831***	***0.7097***	***0.6951***	***0.6364***	***0.0000***	***0.0000***	***0.7936***
24	65	83	14	5	3	0	0	170
	0.2769	***0.6988***	***0.2857***	***0.8000***	***0.3333***	--	--	***0.5000***
25	257	1074	294	54	5	0	4	1688
	0.6965	***0.4953***	***0.5000***	***0.3889***	***0.2000***	--	***0.0000***	***0.5213***
26	0	164	78	23	1	0	0	266
	--	***0.4878***	***0.4487***	***0.0000***	***0.0000***	--	--	***0.4323***
27	154	38	35	8	0	0	0	235
	0.9545	***0.7632***	***0.8000***	***1.0000***	--	--	--	***0.9021***
28	0	0	2	1	0	0	0	3
	--	--	***0.0000***	***0.0000***	--	--	--	***0.0000***
All	5529	9766	1722	674	117	26	18	17852
	0.7576	***0.6073***	***0.4663***	***0.3516***	***0.4530***	***0.7692***	***0.5000***	***0.6297***

Table 10c. Geographic fidelity estimates for Sections (Sec), shown in bold Italics, and numbers of recovered tags shown by the numbers of years at large (years between release and recapture). Tag returns at large for 6 or more years 6 were pooled in the 6-year column.

	Years at large							
	0	1	2	3	4	5	6	All
Sec								
2	31	1	0	0	0	0	0	32
	0.6452	***0.0000***	--	--	--	--	--	***0.6250***
6	358	3	0	0	0	0	0	361
	0.8743	***0.0000***	--	--	--	--	--	***0.8670***
11	1	0	0	0	0	0	0	1
	0.0000	--	--	--	--	--	--	***0.0000***
21	9	11	4	3	0	0	0	27
	0.1111	***0.0909***	***0.2500***	***0.0000***	--	--	--	***0.1111***
23	1	0	0	0	0	0	0	1
	1.0000	--	--	--	--	--	--	***1.0000***
24	9	4	1	0	0	0	0	14
	0.7778	***0.0000***	***0.0000***	--	--	--	--	***0.5000***
25	26	4	2	0	1	0	0	33
	0.2308	***0.2500***	***0.5000***	--	***0.0000***	--	--	***0.2424***
32	1	18	8	0	0	0	0	27
	0.0000	***0.0000***	***0.0000***	--	--	--	--	***0.0000***
33	194	10	3	0	0	0	0	207
	0.4845	***0.3000***	***0.6667***	--	--	--	--	***0.4783***
41	3	0	0	0	0	0	0	3
	0.0000	--	--	--	--	--	--	***0.0000***
42	291	49	0	0	0	0	0	340
	0.6048	***0.6327***	--	--	--	--	--	***0.6088***
43	15	0	0	0	0	0	0	15
	0.4667	--	--	--	--	--	--	***0.4667***
51	0	23	1	5	0	0	0	29
	--	***0.0435***	***0.0000***	***0.0000***	--	--	--	***0.0345***
52	701	19	5	0	1	0	0	726
	0.9444	***0.4211***	***0.4000***	--	***0.0000***	--	--	***0.9256***
59	1	1	0	0	0	0	0	2
	0.0000	***0.0000***	--	--	--	--	--	***0.0000***

Table 10c. Continued. Geographic fidelity estimates for Sections (Sec), shown in bold Italics, and numbers of recovered tags shown by the numbers of years at large (years between release and recapture). Tag returns at large for 6 or more years 6 were pooled in the 6-year column.

	Years at large							
	0	1	2	3	4	5	6	All
Sec								
61	0	2	0	0	0	0	0	2
	--	***0.0000***	--	--	--	--	--	***0.0000***
64	1	0	0	0	0	0	0	1
	0.0000	--	--	--	--	--	--	***0.0000***
65	0	5	0	0	0	0	0	5
	--	***0.0000***	--	--	--	--	--	***0.0000***
66	0	230	22	1	0	0	0	253
	--	***0.0913***	***0.0455***	***0.0000***	--	--	--	***0.0870***
67	173	155	84	4	1	0	0	417
	0.7283	***0.5290***	***0.0595***	***0.2500***	***0.0000***	--	--	***0.5132***
71	1	0	0	0	0	0	0	1
	0.0000	--	--	--	--	--	--	***0.0000***
72	378	71	12	0	1	1	0	463
	0.1455	***0.1268***	***0.0000***	--	***0.0000***	***0.0000***	--	***0.1382***
73	5	0	0	0	0	0	0	5
	0.0000	--	--	--	--	--	--	***0.0000***
74	83	16	3	0	0	0	0	102
	0.4217	***0.3750***	***0.3333***	--	--	--	--	***0.4118***
75	3	0	0	0	0	0	0	3
	0.0000	--	--	--	--	--	--	***0.0000***
76	0	0	2	1	0	0	0	3
	--	--	***1.0000***	***0.0000***	--	--	--	***0.6667***
77	32	3	0	1	0	0	0	36
	0.3125	***0.0000***	--	***0.0000***	--	--	--	***0.2778***
79	1	0	0	0	0	0	0	1
	0.0000	--	--	--	--	--	--	***0.0000***
85	179	467	84	42	10	0	0	782
	0.7039	***0.0236***	***0.0000***	***0.3333***	***0.0000***	--	--	***0.1931***
89	0	251	9	0	0	0	0	260
	--	***0.0000***	***0.0000***	--	--	--	--	***0.0000***
93	0	7	0	0	1	0	0	8
	--	***0.0000***	--	--	***0.0000***	--	--	***0.0000***

Table 10c. Continued. Geographic fidelity estimates for Sections (Sec), shown in bold Italics, and numbers of recovered tags shown by the numbers of years at large (years between release and recapture). Tag returns at large for 6 or more years 6 were pooled in the 6-year column.

	Years at large							
	0	1	2	3	4	5	6	All
Sec								
102	0	1	0	0	0	0	0	1
	--	*0.0000*	--	--	--	--	--	*0.0000*
121	3	14	2	0	1	0	0	20
	0.0000	*0.0000*	*0.0000*	--	*0.0000*	--	--	*0.0000*
122	1	0	0	0	0	0	0	1
	0.0000	--	--	--	--	--	--	*0.0000*
123	5	183	87	15	6	1	1	298
	0.2000	*0.5902*	*0.6322*	*0.5333*	*0.5000*	*1.0000*	*1.0000*	*0.5940*
124	0	22	4	0	3	0	0	29
	--	*0.0000*	*0.0000*	--	*0.0000*	--	--	*0.0000*
125	0	3	2	0	1	0	0	6
	--	*0.6667*	*1.0000*	--	*0.0000*	--	--	*0.6667*
126	0	8	1	1	5	0	0	15
	--	*0.0000*	*0.0000*	*0.0000*	*1.0000*	--	--	*0.3333*
132	79	201	63	21	6	1	0	371
	0.9367	*0.2090*	*0.2540*	*0.3333*	*0.1667*	*0.0000*	--	*0.3774*
135	6	0	0	0	0	0	0	6
	0.1667	--	--	--	--	--	--	*0.1667*
136	0	1	0	0	0	0	0	1
	--	*0.0000*	--	--	--	--	--	*0.0000*
141	0	0	1	0	0	0	0	1
	--	--	*0.0000*	--	--	--	--	*0.0000*
142	98	104	63	8	0	1	0	274
	0.0306	*0.1250*	*0.1746*	*0.0000*	--	*0.0000*	--	*0.0985*
143	4	2	1	0	0	0	0	7
	0.0000	*0.5000*	*0.0000*	--	--	--	--	*0.1429*
152	86	6	2	0	0	0	0	94
	0.1047	*0.0000*	*0.0000*	--	--	--	--	*0.0957*
162	1	0	0	0	0	0	0	1
	0.0000	--	--	--	--	--	--	*0.0000*
163	5	0	0	0	0	0	0	5
	1.0000	--	--	--	--	--	--	*1.0000*

Table 10c Continued. Geographic fidelity estimates for Sections (Sec), shown in bold Italics, and numbers of recovered tags shown by the numbers of years at large (years between release and recapture). Tag returns at large for 6 or more years 6 were pooled in the 6-year column.

	Years at large							
	0	1	2	3	4	5	6	All
Sec								
171	0	6	4	0	0	0	0	10
	--	***0.0000***	***0.0000***	--	--	--	--	***0.0000***
172	39	162	41	8	1	2	0	253
	0.0513	***0.1543***	***0.0244***	***0.1250***	***0.0000***	***0.0000***	--	***0.1146***
173	700	130	32	3	3	0	0	868
	0.9829	***0.3692***	***0.0937***	***0.0000***	***0.0000***	--	--	***0.8514***
181	118	530	94	22	1	0	1	766
	0.7034	***0.1887***	***0.0957***	***0.3636***	***0.0000***	--	***1.0000***	***0.2624***
182	2	0	0	0	0	0	0	2
	0.0000	--	--	--	--	--	--	***0.0000***
193	1	4	1	0	0	0	0	6
	0.0000	***0.0000***	***0.0000***	--	--	--	--	***0.0000***
202	0	1	0	0	0	0	0	1
	--	***1.0000***	--	--	--	--	--	***1.0000***
219	3	766	35	0	0	0	0	804
	0.3333	***0.0000***	***0.1714***	--	--	--	--	***0.0087***
231	6	0	2	0	0	0	0	8
	0.1667	--	***0.5000***	--	--	--	--	***0.2500***
232	178	26	7	1	0	0	0	212
	0.4663	***0.3462***	***0.4286***	***1.0000***	--	--	--	***0.4528***
233	4	7	2	1	0	0	0	14
	0.2500	***0.1429***	***0.0000***	***0.0000***	--	--	--	***0.1429***
239	2	0	0	0	0	0	0	2
	0.5000	--	--	--	--	--	--	***0.5000***
241	2	1	0	1	0	0	0	4
	0.0000	***0.0000***	--	***0.0000***	--	--	--	***0.0000***
243	5	45	9	3	3	0	0	65
	0.8000	***0.2222***	***0.1111***	***0.3333***	***0.3333***	--	--	***0.2615***
244	0	0	1	0	0	0	0	1
	--	--	***0.0000***	--	--	--	--	***0.0000***

Table 10c. Continued. Geographic fidelity estimates for Sections (Sec), shown in bold Italics, and numbers of recovered tags shown by the numbers of years at large (years between release and recapture). Tag returns at large for 6 or more years 6 were pooled in the 6-year column.

	Years at large							
	0	1	2	3	4	5	6	All
Sec								
245	27	1	0	0	0	0	0	28
	0.0370	***0.0000***	--	--	--	--	--	***0.0357***
252	5	176	26	0	1	0	0	208
	0.0000	***0.1250***	***0.2692***	--	***0.0000***	--	--	***0.1394***
253	23	670	202	49	4	0	1	949
	0.6957	***0.2657***	***0.4208***	***0.3265***	***0.2500***	--	***0.0000***	***0.3119***
263	0	4	47	19	1	0	0	71
	--	***0.0000***	***0.5532***	***0.0000***	***0.0000***	--	--	***0.3662***
273	0	0	1	0	0	0	0	1
	--	--	***0.0000***	--	--	--	--	***0.0000***
280	0	0	2	1	0	0	0	3
	--	--	***0.0000***	***0.0000***	--	--	--	***0.0000***
All	3900	4424	972	210	51	6	3	9566
	0.6700	***0.1659***	***0.2479***	***0.2714***	***0.2157***	***0.1667***	***0.6667***	***0.3825***

Table 11a. **Geographic fidelity estimates for Regions**, estimated for tags released and recovered during the spawning period (February-April). For each region, the data are presented in two rows. The top row indicates the numbers recovered in each region as a function of the numbers of years or release. The second row shows the same information, as a frequency, or 'fidelity rate' (in bold). For example, a fidelity rate of 0.7568 for QCI means that 75.68 % of the tags were recovered in QCI after one year of release in QCI. A fidelity rate of 1.0 means that all of the recovered tags were released in the area of recovery and a recovery rate of 0.0 means that none of the recovered tags was released in the area of recovery. Note that the fidelity rate for all regions, is about 0.9 for recovery and release withiinn the same year, and after 1 and 2 years is about 0.8.

	Years at large						
	0	1	2	3	4	5	All
Region							
QCI	533	74	7	3	1	0	618
	0.8931	***0.7568***	***1.0000***	***1.0000***	***1.0000***	--	***0.8786***
PRD	1091	31	7	0	1	0	1130
	0.9093	**0.8065**	**1.0000**	--	**1.0000**	--	**0.9071**
CC	723	97	20	1	3	1	845
	0.8783	***0.8144***	***0.7500***	***1.0000***	***1.0000***	***1.0000***	***0.8686***
JS	65	2	2	0	0	0	69
	0.9538	***0.0000***	***0.0000***	--	--	--	***0.8986***
SOG	325	36	5	3	0	0	369
	0.8215	***0.7500***	***0.6000***	***1.0000***	--	--	***0.8130***
WCVI	1058	81	19	1	0	0	1159
	0.9244	***0.8025***	***0.8947***	***1.0000***	--	--	***0.9154***
All	3795	321	60	8	5	1	4190
	0.8986	***0.7850***	***0.8167***	***1.0000***	***1.0000***	***1.0000***	***0.8890***

Table 11b. **Geographic fidelity estimates for Statistical Areas** (SA) estimated from spawning period (February-April) releases and recoveries, shown in bold Italics, and numbers of recovered tags shown by the numbers of years at large (years between release and recapture). All returns are from anchor tagging recoveries. No recovered tag was at large for more than 5 years.

	Years at large						
	0	1	2	3	4	5	All
SA							
0	459	26	3	1	0	0	489
	0.8646	***0.3846***	***0.3333***	***0.0000***	--	--	***0.8340***
2	74	48	4	2	1	0	129
	0.9054	***0.7292***	***0.7500***	***1.0000***	***1.0000***	--	***0.8372***
3	204	14	3	0	0	0	221
	0.4876	***0.2143***	***0.6667***	--	--	--	***0.4725***
4	64	5	2	0	1	0	72
	0.1875	***0.6000***	***0.0000***	--	***0.0000***	--	***0.2083***
5	823	12	2	0	0	0	837
	0.8291	***0.7273***	***1.0000***	--	--	--	***0.8282***
6	222	9	2	0	1	0	234
	0.6232	***0.0000***	***0.0000***	--	***0.0000***	--	***0.5890***
7	496	81	15	1	1	1	595
	0.7778	***0.8250***	***0.7333***	***1.0000***	***1.0000***	***1.0000***	***0.7843***
8	5	6	3	0	0	0	14
	0.0000	***0.0000***	***0.0000***	--	--	--	***0.0000***
9	0	1	0	0	1	0	2
	--	***0.0000***	--	--	***0.0000***	--	***0.0000***
13	65	2	2	0	0	0	69
	0.9538	--	***0.0000***	--	--	--	***0.9254***
14	112	14	0	1	0	0	127
	0.7500	***0.7500***	--	***0.0000***	--	--	***0.7434***
15	62	7	0	0	0	0	69
	0.1333	***0.0000***	--	--	--	--	***0.1154***
16	1	1	0	0	0	0	2
	0.0000	***0.0000***	--	--	--	--	***0.0000***
17	93	12	5	0	0	0	110
	0.1429	***0.0000***	***0.0000***	--	--	--	***0.1159***

Table 11b. Continued. **Geographic fidelity estimates for Statistical Areas** (SA) estimated from spawning period (February-April) releases and recoveries, shown in bold Italics, and numbers of recovered tags shown by the numbers of years at large (years between release and recapture). All returns are from anchor tagging recoveries. No recovered tag was at large for more than 5 years.

	Years at large						
	0	1	2	3	4	5	All
SA							
18	57	2	0	2	0	0	61
	0.0000	***0.0000***	--	***0.0000***	--	--	***0.0000***
23	772	50	11	1	0	0	834
	0.8447	***0.8367***	***0.6364***	***1.0000***	--	--	***0.8414***
24	89	22	8	0	0	0	119
	0.2022	***0.0455***	***0.0000***	--	--	--	***0.1597***
25	196	5	0	0	0	0	201
	0.9162	***0.0000***	--	--	--	--	***0.8929***
27	1	4	0	0	0	0	5
	0.0000	***0.0000***	--	--	--	--	***0.0000***
All	3795	321	60	8	5	1	4190
	0.7527	***0.5677***	***0.4333***	***0.5714***	***0.4000***	***1.0000***	***0.7326***

Table 11c. **Geographic fidelity estimates for Sections** (Sec) estimated from spawning period (February-April) releases and recoveries, shown in bold Italics, and numbers of recovered tags shown by the numbers of years at large (years between release and recapture). All returns are from anchor tagging recoveries. No recovered tag was at large for more than 5 years.

	Years at large						
	0	1	2	3	4	5	All
Sec							
2	30	2	1	0	0	0	33
	0.7143	--	--	--	--	--	***0.7143***
3	80	9	0	0	0	0	89
	0.0000	--	--	--	--	--	***0.0000***
5	0	3	0	0	0	0	3
	--	--	--	--	--	--	--
6	349	12	2	1	0	0	364
	0.9152	***0.0000***	***0.0000***	***0.0000***	--	--	***0.9020***
21	58	24	2	0	0	0	84
	0.0769	***0.1250***	***1.0000***	--	--	--	***0.1364***
23	0	2	0	0	1	0	3
	--	***0.0000***	--	--	***0.0000***	--	***0.0000***
24	7	3	0	0	0	0	10
	1.0000	***0.0000***	--	--	--	--	***0.7000***
25	9	19	2	2	0	0	32
	0.6667	***0.0909***	***0.5000***	***0.0000***	--	--	***0.3333***
32	36	0	1	0	0	0	37
	0.0000	--	***0.0000***	--	--	--	***0.0000***
33	168	14	2	0	0	0	184
	0.5924	***0.2308***	***1.0000***	--	--	--	***0.5698***
42	56	5	1	0	1	0	63
	0.0962	***0.6000***	***0.0000***	--	***0.0000***	--	***0.1356***
43	8	0	1	0	0	0	9
	0.8750	--	***0.0000***	--	--	--	***0.7778***
52	823	12	2	0	0	0	837
	0.8429	***0.7273***	***1.0000***	--	--	--	***0.8417***
67	222	9	2	0	1	0	234
	0.3214	***0.0000***	***0.0000***	--	--	--	***0.2935***

Table 11c. Continued. **Geographic fidelity estimates for Sections** (Sec) estimated from spawning period (February-April) releases and recoveries, shown in bold Italics, and numbers of recovered tags shown by the numbers of years at large (years between release and recapture). All returns are from anchor tagging recoveries. No recovered tag was at large for more than 5 years.

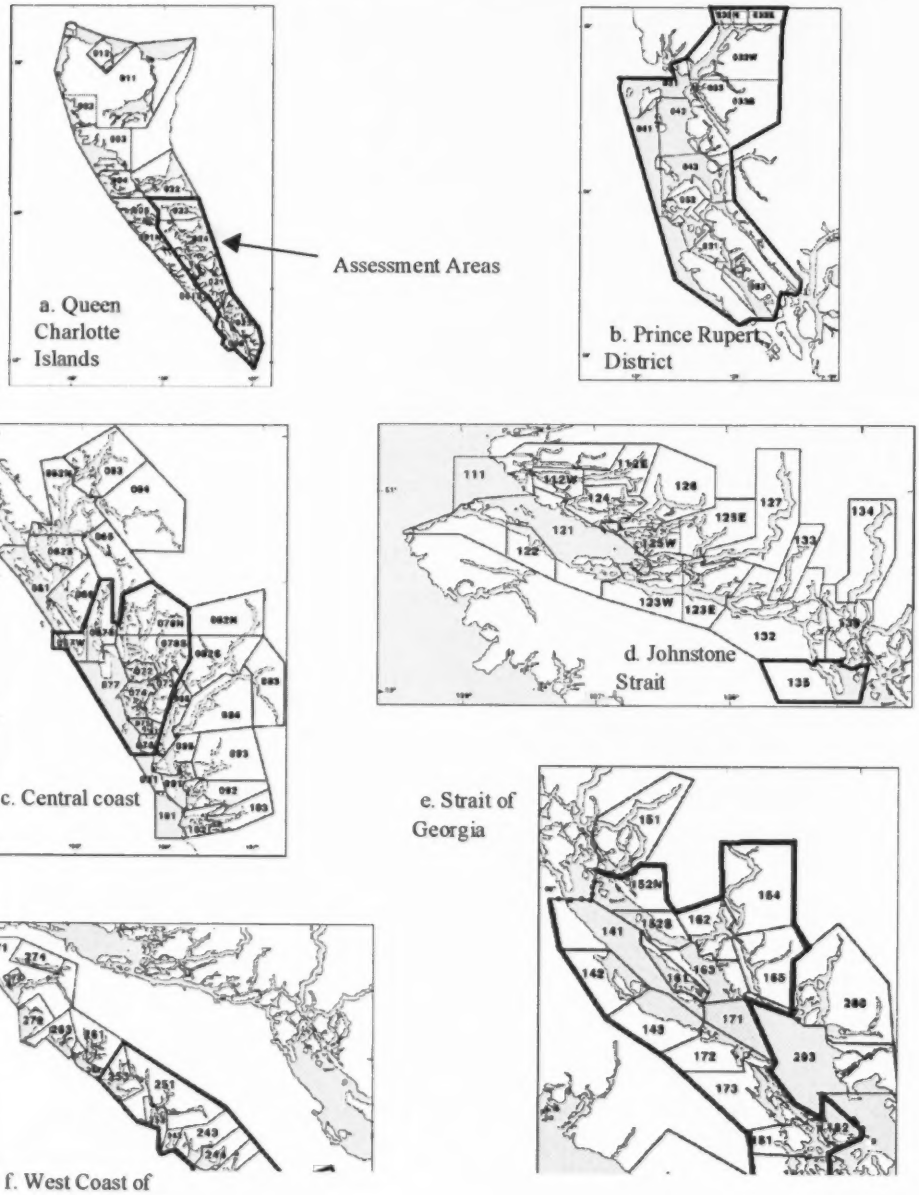
	Years at large						
	0	1	2	3	4	5	All
Sec							
72	67	13	0	0	0	0	80
	0.8871	***0.6923***	--	--	--	--	***0.8533***
73	57	6	0	0	0	0	63
	0.0000	***0.0000***	--	--	--	--	***0.0000***
74	277	43	13	1	0	1	335
	0.1570	***0.1667***	***0.0833***	***0.0000***	--	***0.0000***	***0.1538***
75	0	1	0	0	0	0	1
	--	***0.0000***	--	--	--	--	***0.0000***
76	12	4	0	0	1	0	17
	0.0000	***0.0000***	--	--	***0.0000***	--	***0.0000***
77	83	2	0	0	0	0	85
	0.1538	***0.0000***	--	--	--	--	***0.1515***
78	0	12	2	0	0	0	14
	--	***0.0000***	***0.0000***	--	--	--	***0.0000***
85	5	6	3	0	0	0	14
	0.0000	***0.0000***	***0.0000***	--	--	--	***0.0000***
93	0	1	0	0	1	0	2
	--	***0.0000***	--	--	--	--	***0.0000***
132	61	0	0	0	0	0	61
	0.9322	--	--	--	--	--	***0.9322***
135	4	2	2	0	0	0	8
	0.0000	--	***0.0000***	--	--	--	***0.0000***
142	112	12	0	0	0	0	124
	0.1538	***0.6667***	--	--	--	--	***0.2500***
143	0	2	0	1	0	0	3
	--	***0.5000***	--	***0.0000***	--	--	***0.3333***
152	62	7	0	0	0	0	69
	0.5455	***0.0000***	--	--	--	--	***0.4000***
162	1	1	0	0	0	0	2
	--	--	--	--	--	--	--
172	32	2	1	0	0	0	35
	0.1667	--	***0.0000***	--	--	--	***0.1429***

Table 11c. Continued. **Geographic fidelity estimates for Sections** (Sec) estimated from spawning period

(February-April) releases and recoveries, shown in bold Italics, and numbers of recovered tags shown by the numbers of years at large (years between release and recapture). All returns are from anchor tagging recoveries. No recovered tag was at large for more than 5 years.

	Years at large						
	0	1	2	3	4	5	All
Sec							
173	61	10	4	0	0	0	75
	0.3333	***0.0000***	***0.0000***	--	--	--	***0.1818***
181	54	2	0	2	0	0	58
	0.0000	--	--	***0.0000***	--	--	***0.0000***
231	29	5	0	0	0	0	34
	0.0000	***0.0000***	--	--	--	--	***0.0000***
232	598	38	6	1	0	0	643
	0.6148	***0.7500***	***0.6000***	***1.0000***	--	--	***0.6275***
233	145	7	5	0	0	0	157
	0.0000	***0.0000***	***0.0000***	--	--	--	***0.0000***
242	0	1	1	0	0	0	2
	--	***0.0000***	***0.0000***	--	--	--	***0.0000***
243	75	12	5	0	0	0	92
	0.5714	***0.0000***	--	--	--	--	***0.4444***
244	10	5	1	0	0	0	16
	0.0000	***0.0000***	--	--	--	--	***0.0000***
245	4	4	1	0	0	0	9
	0.2500	***0.0000***	--	--	--	--	***0.1250***
252	140	3	0	0	0	0	143
	0.0000	***0.0000***	--	--	--	--	***0.0000***
253	56	2	0	0	0	0	58
	1.0000	--	--	--	--	--	***1.0000***
272	0	3	0	0	0	0	3
	--	***0.0000***	--	--	--	--	***0.0000***
273	1	1	0	0	0	0	2
	0.0000	--	--	--	--	--	***0.0000***
All	3795	321	60	8	5	1	4190
	0.6076	***0.2416***	***0.2381***	***0.1429***	***0.0000***	***0.0000***	***0.5737***

Fig. 1. Herring stock assessment regions showing the six herring Regions. Within each region are Statistical Areas (identifed by the first two digits in the numbers) and Sections. The sections included in the annual stock assessments are outlined in bold.



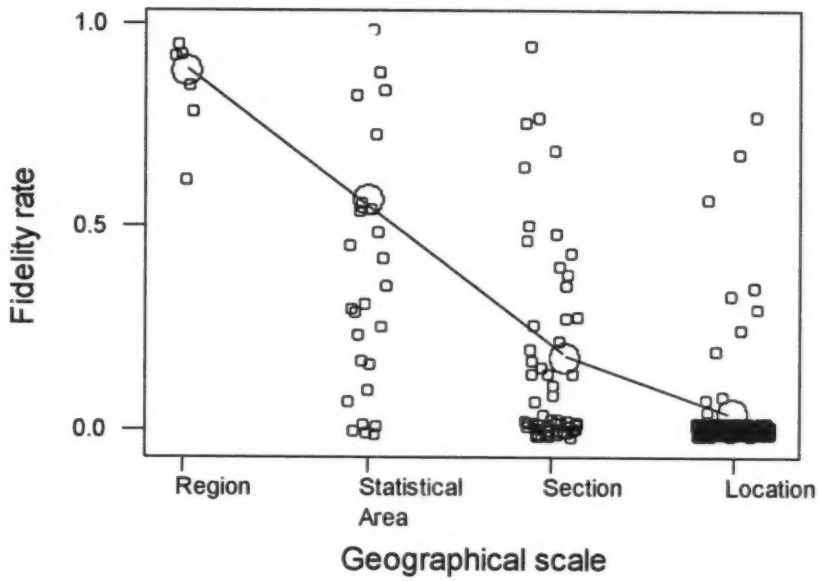


Fig. 2. Comparison of fidelity rates by Regions, Statistical Areas, Sections and Locations. The array of small points (jittered horizontally to reduce overlap) each represent the mean fidelity of different geographic unit within each geographic category (i.e. there are 6 regions and 6 points). Some of the highest points in the Statistcal Area and Section categories are based on very small samples sizes. The larger circles represent the overall mean fidelity for each geographic category.

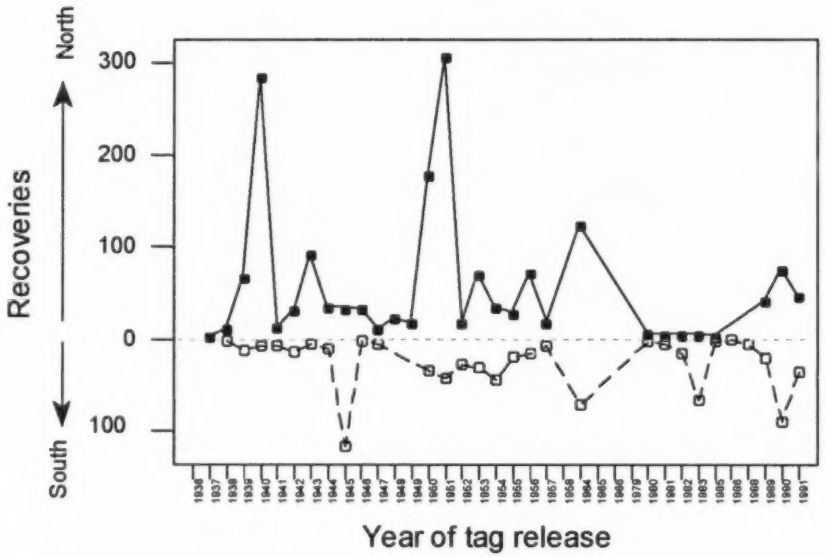


Fig. 3. Movements north or south determined from the release and recapture positions of tagged herring shown by the year of release. Most of the movements occurred in the Central and Prince Rupert Districts.

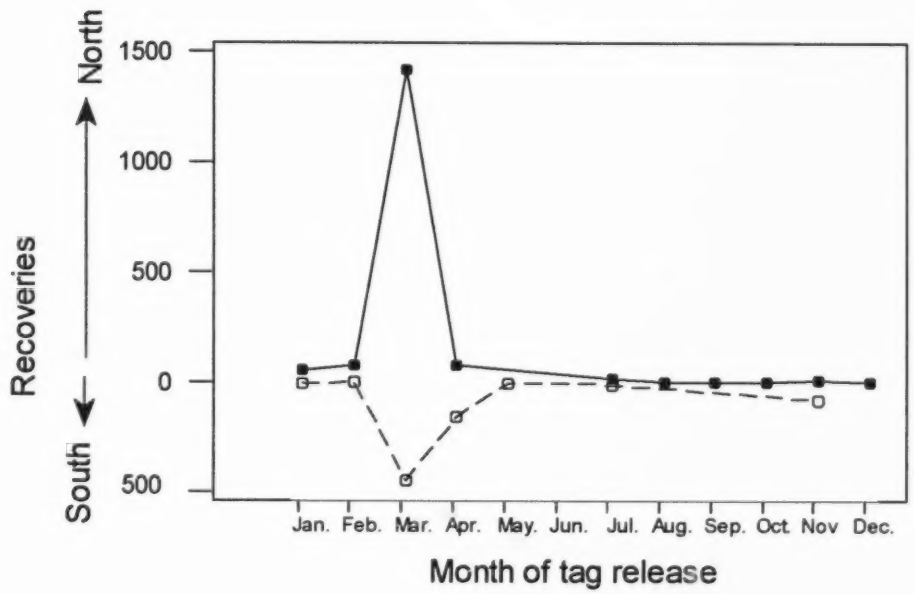


Fig. 4. Movements north or south determined from the release and recapture positions of tagged herring shown by the month of tag release. Most of the movements occurred in the Central and Prince Rupert Districts.